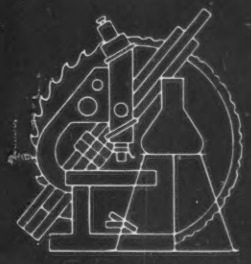
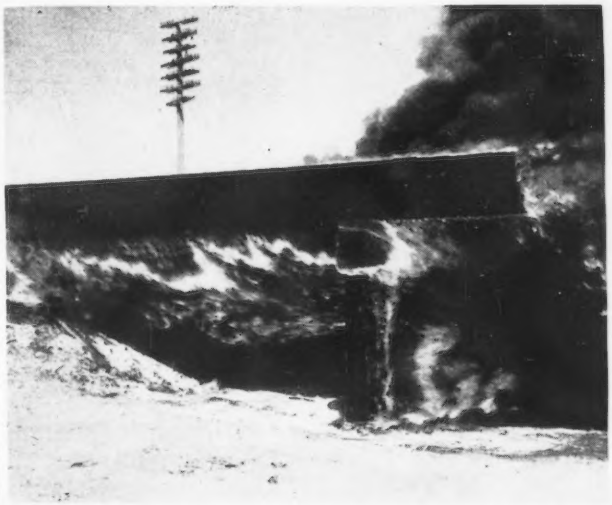
Forest Products Journal

Directory of 300 FPRS Officers and Committee Members

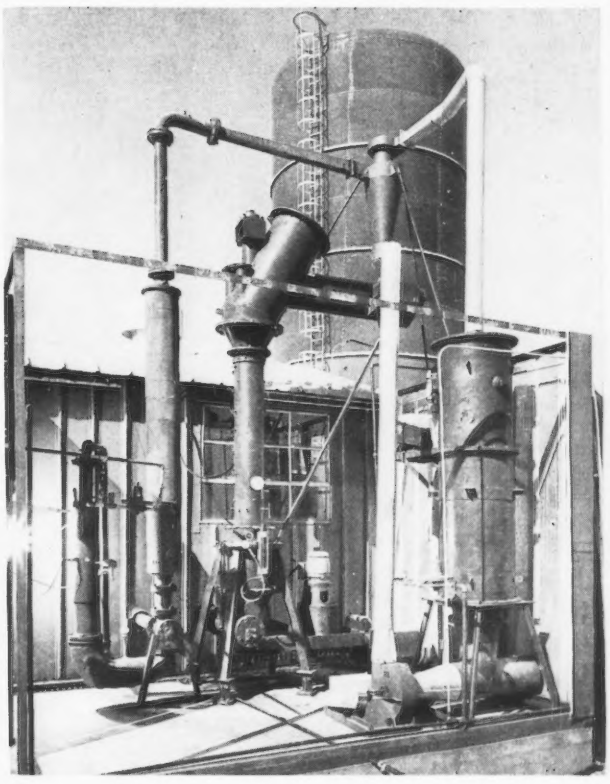


1959 "YEARBOOK" ISSUE

Fersolin - - - Fertilizer from Sawdust, page 340

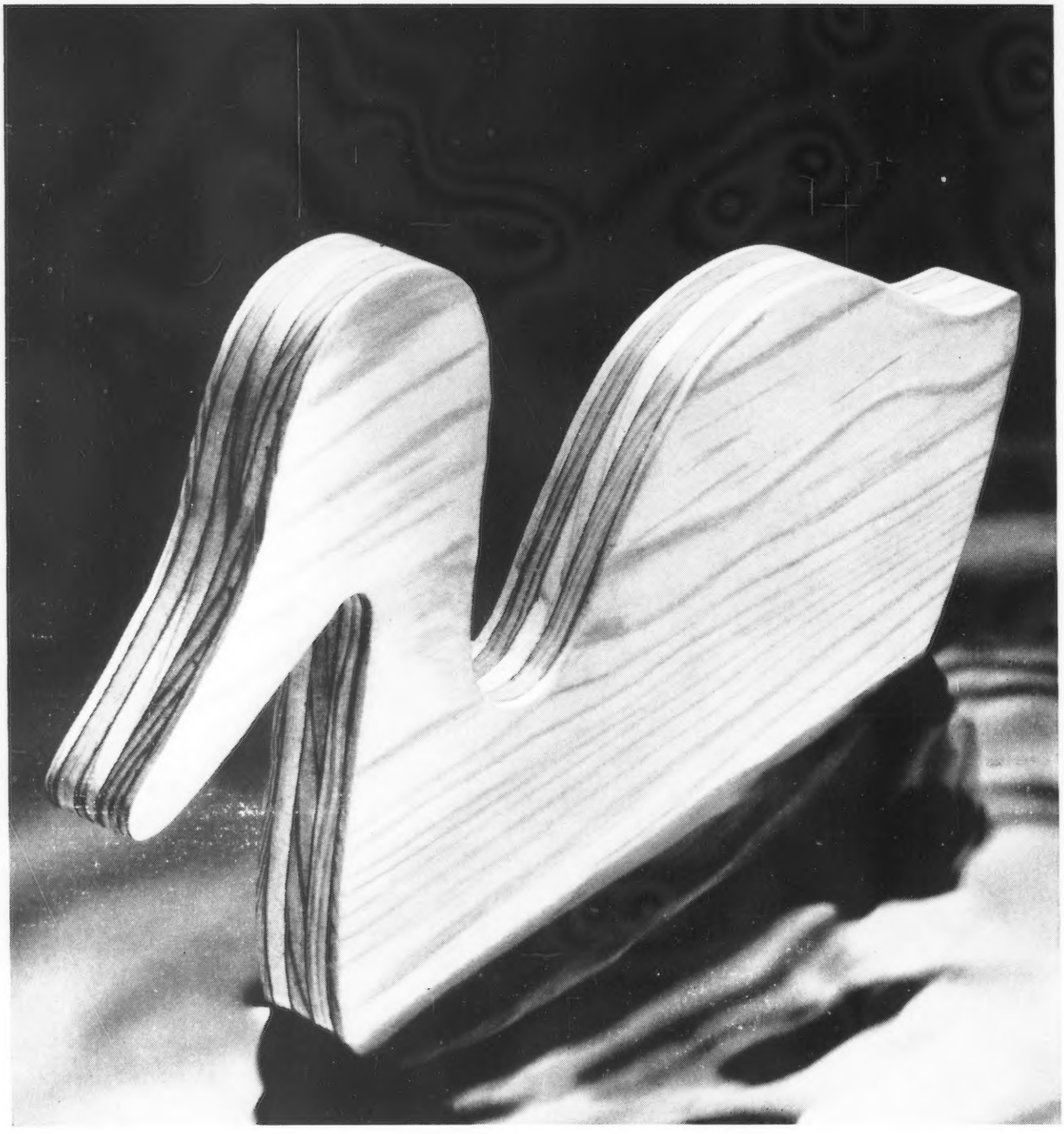


General Gavin Speaks out on Research - - - is it headed in the right direction ? page 323



Fire-Retardants for Railroad Trestles. Fire hit 900°c, Flames out in 8 minutes, page 325

Published by the FOREST PRODUCTS RESEARCH SOCIETY BOX 2010 MADISON 5, WISCONSIN



WHEN IS A GLUE LINE LIKE A DUCK'S BACK? *When you use new* MELURAC® *305 adhesive resin!* With any wood, you can get waterproof bonds surpassing FHA specifications, Commercial Specifications CS 35-56, and the toughest Military Specs. MELURAC 305, a melamine-urea adhesive, easily takes the double cyclic four-hour boil. You get these superior results *at no increase in price.* It's non-staining, quick-setting, long-working, easy to handle and cures at moderate temperatures. Shrug off tough waterproof bond specs for block flooring, veneered doors and exterior and marine grade plywoods with MELURAC 305.

CYANAMID

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
328 Rockefeller Plaza, New York 20, New York

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York • Oakland • Philadelphia • St. Louis • Seattle

FOREST PRODUCTS JOURNAL

Vol. IX, No. 10 October, 1959

CONTENTS

EDITORIAL

"Let's Move Forward with New Ideas" ..... *Lt. General James N. Gavin, Ret.* 323
General Gavin speaks out on basic research—Are we headed in the right direction?

FIRE RETARDANTS

Fire Retardants for Wood Treated with Oil-Type Preservatives ..... *R. M. Gooch, D. L. Kenaga, and H. M. Tobey* 325
Tests showed that a phosphorus-halogen mixture reduced fire hazard in trestles.

PARTICLE BOARD AND WOOD MOLDING

A Search for Better Particle Board Adhesives ..... *J. W. Maxwell, G. Kitazawa, T. F. Duncan, and J. M. Hine* 42-A
Phenolic-bonded particle boards produce a product with properties suitable for many markets, but specifications must be set by consumers, manufacturers, and trade associations.

Effect of Formation Variables on Properties of Wood Particle Moldings ..... *T. J. Patterson and J. D. Snodgrass* 330
Pressure, resin content, and moisture content effect properties; improved properties can be obtained by varying moisture content.

GLUES AND GLUING

Elastomeric Adhesives—Their Uses in Forest Products ..... *C. C. Booth, C. P. Hancock, and J. M. Hine* 337
Elastomeric adhesives are versatile; they can be used to bond wood products to metal, foils, plastics, and fabrics.

UTILIZATION

Process for Converting Sawdust into Fertilizer .... *E. Farber and R. R. Hind* 340
Sawmill residues treated with acid and fortified with nutrients make an efficient soil conditioner.

Pulping Sawdust Chips Made by a Coarse Feed Saw ..... *J. S. Martin* 359
Sawdust from a new saw produces pulp with bursting and tearing strengths up to 85 percent of the values for regular pulp.

Heartwood Content of Douglas-Fir Mill Residues ..... *R. M. Samuels and D. W. Glennie* 384
Chips from veneer trim plus cores contained the most heartwood.

PLYWOOD

A New Performance Test for Interior Plywood and Its Application to Panels Containing White-Pocket Veneer ..... *R. H. Ripley* 344
Presents an effective method for quality-control evaluation of white-pocket plywood.

1959 "WOOD AWARD"

Transverse Anistropy of Wood: A Function of Gross Anatomic Structure ..... *A. P. Schniewind* 350
The author finds properties and alignment of rays are primary causes of diffeernces between tangential and radial values of modulus of elasticity, tensile strength, and shrinkage.

MACHINING

Circular Sawing Experiments on a Radial Arm Saw ..... *C. W. McMillin and J. L. Lubkin* 361
The determination of net power required to saw certain woods under various conditions.

Editor
John K. McDonald, Madison, Wis.
International Editor
R. W. Wellwood
President
E. S. Harrar, Durham, N. C.
President-Elect
R. H. Berry, Burney, Calif
Vice President
D. K. Saunders, Westbrook, Maine
Past President
W. J. Eason, Memphis, Tenn.
Executive Secretary
Frank J. Rovsek, Madison, Wis.

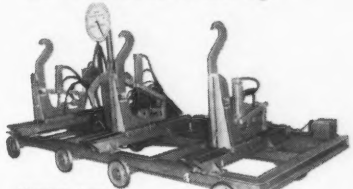
THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, 417 North Walnut Street, Madison 5, Wisconsin. Second-class postage paid at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

7 different MATER CARRIAGES

Sawyers prefer a Mater Carriage.
With a flick of a switch he can make a Mater Carriage do everything he wants, instantly, accurately. Mater gives him time to think and to get the best grade out of each log.



MATER MIDDLEWEIGHT
for small logs.

MATER "42"
for small logs, high production.

MATER STANDARD DUTY
for heavy small logs.

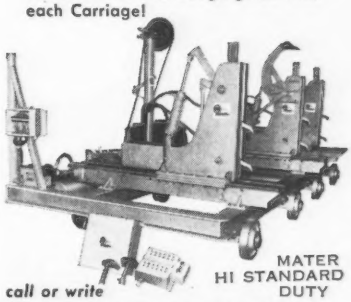
MATER HI STANDARD DUTY
for large logs, high production.

MATER GIANT
heavy duty—precision with muscle.

MATER SUPER GIANT
very heavy duty for very large logs.

MATER SPECIAL CARRIAGES
for special purpose.

All Mater Riderless Carriages equipped with Mater Auto-Set Automatic Setworks. Test the accuracy of Mater Carriages Yourself. A Mater Lumber Thickness Gauge given with each Carriage!



call or write
MATER MACHINE WORKS, INC.
P. O. Box 410 • Corvallis, Oregon, U.S.A.
Phone: PLaza 3-7335

MATER SAWMILL AUTOMATION EQUIPMENT
SPECIALISTS IN AUTOMATION FOR THE FOREST PRODUCTS INDUSTRY

Sel-Set®

ALL NEW
ALL PURPOSE
"MODEL M3LC"
SELECT-⊙-MATIC
PREDETERMINING REMOTE CONTROL
ELECTRONIC SETWORKS
FOR RIDERLESS SAWMILL CARRIAGES

- EVEN GREATER ACCURACY
- TAKES ONLY 1/5 THE FLOOR SPACE OF THE M2LC

Now, through continuing engineering advancements in design and performance, Sel-Set, the leader in carriage automation, is able to offer you the all new, all purpose M3LC . . . A setworks especially designed for all mills, regardless of sawbox limitations, who want the very best in setworks performance. This new Select-O-Matic replaces the famous Sel-Set M2LC all-purpose setworks, the only truly all-purpose remote control carriage setworks ever available.

A completely redesigned sawyer's control console for the M3LC has been decreased in every dimension as compared with the former M2LC models so that now every mill can have the advantages of this exclusive all-purpose type of setworks regardless of the size of the sawbox.

Although smaller, the new console provides greater accuracy than ever before for all infinite settings and incorporates even more controls, 32 in all, than the M2LC. Floor space is only 1/5 that of former models and leg room is practically unrestricted.

If you are looking for top performance and production . . . don't settle for less than the best. The new M3LC Electronic Setworks is available for immediate installation. Investigate today and find out why Sel-Set engineering is the most copied in the lumber industry.

Other Sel-Set setworks available in models and sizes for any size or type of mill operation. Original Sel-Set double motor in line Power-Pak available for all models.

WRITE, WIRE OR PHONE FOR DETAILED INFORMATION AND PRICE QUOTATIONS

Authorized Sel-Set Dealers:

THE WHELAND CO.
Chattanooga, Tennessee

GENERAL MACHY. CO.
Spokane, Washington

KLAMATH MACHY. CO.
Klamath Falls, Oregon

MILLER MACHY. CO.
Missoula, Montana

NORTHEAST OHIO MACHINE BUILDERS
Columbiana, Ohio

FRED E. BARNETT CO.
Eureka, Ukiah
Sacramento, San Francisco

SEL-SET
Machinery Corporation

290 Moyer Lane, P.O. Box 1035, Salem, Ore.
EMpire 3–3123

Available in Canada through Elworthy & Co., Ltd., Licensed Manufacturers, Vancouver, B.C.

Management's Decision: Automate the Sawmill ..... *M. H. Mater* 33-A
Gains with automation outweigh costs. Author presents practical methods of improving production efficiency.

Trend in Wood Sanding: Wide Belts ..... *H. L. Bennett* 39-A
New equipment results in improved finishes, increased production, and lower costs . . . these advantages spell profits.

WOOD PROPERTIES

New Method of Calculating Internal Stresses in Wood ..... *R. L. Youngs and C. B. Norris* 367
Presents a method for calculating perpendicular-to-grain stresses in cross-sections of boards.

PRESERVATION AND DIMENSIONAL STABILITY

Dyes for Preserving Wood ..... *J. W. Weaver, E. B. Jeroski, I. S. Goldstein* 372
Presents results of tests of 41 textile dye and rates their effectivness as wood preservatives.

Effect of Polyethylene Glycol on The Dimensional Stability of Wood ..... *A. J. Stamm* 375
Describes a method for simultaneously seasoning wood and giving it dimensional stability.

Preserving Lumber in Storage ..... *R. J. Miller* 390
Preservatives prevent decay for more than 4 years in southern climates.

CHEMISTRY OF ASPEN WOOD

Separating Lignosulfonates from Carbohydrates in Aspen Spent Sulfite Liquor by Ion Exchange ..... *I. A. Pearl and D. L. Beyer* 381
Shows how separation can be obtained by decationizing the spent liquor and passing it over a regenerated column of Duolite-A-2M.

PACKAGING

Cushioning for Packaging: Engineering Wood Cellulose ..... *C. E. Swanson and A. J. Withoff* 35-A
Cellulose fiber felt is a versatile cushioning material suitable for use with products of extremely varied fragiltiies.

QUALITY CONTROL

Methods and Machines for Quality Control of Forest Products ..... *O. J. Black* 386
Describes IBM 650 computer, a machine that provides the solution to problems in minutes.

YEARBOOK SECTION

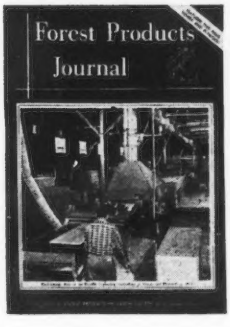
FPRS National Meeting 50-A
Photo Highlights of 13th National Meeting 51-A
List of Wood-Industry Suppliers Who Served as Hosts 59-A
Visits to a Variety of Wood-Industry Plants and Laboratories 61-A
Entertaining Program Enjoyed by 158 Ladies 63-A
1959 Exhibit Attracts 12 Booth and 16 Table Exhibitors 65-A
Employment Committee Activities 64-A
Reports of Tellers and Resolutions Committees 71-A
Sections Plan Grass Roots Recruiting Campaign 73-A
Divisions Seek Legal Status 75-A
Minutes of Division Meetings 75-A
Know Your FPRS Officers and Committees 89-A

DEPARTMENTS

FPRS News Digest 25-A
Around the World in Forest Products Research 47-A
Abstracts from Current World Literature 49-A
Index to Advertisers 96-A

A Thoughtful Gift for Clients and Customers

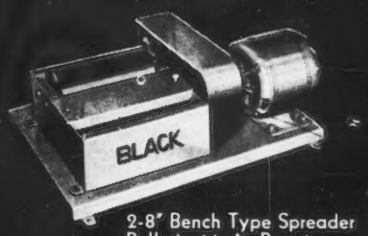
A One Year Membership in FPRS



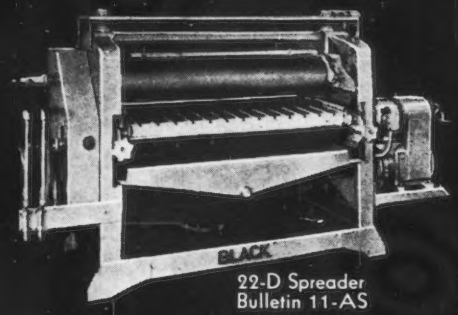
Send us the name and address of the persons you want enrolled. We'll do the rest. A card will show that you are the donor. We will invoice you separately for a total cost of $15.

—Including the Forest Products Journal

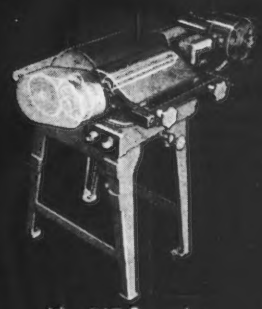
417 N. Walnut St., Madison 5, Wisconsin
FOREST PRODUCTS RESEARCH SOCIETY



2-8" Bench Type Spreader
Bulletin 11-A, Part 1



22-D Spreader
Bulletin 11-AS


No. 567 Spreader
Bulletin 11-A, Part 2

Case Clamp
Bulletin 11-J

First in Production, Quality, Economy

BLACK BROTHERS EQUIPMENT

. . . for gluing, clamping, laminating

GLUE SPREADERS

The most complete line in the world—for hot or cold glues. Single or double spreaders from 8" through 122" roll widths.

GLUE MIXERS AND HEATERS

Cold Glue Mixers—10 to 400 gal.; Portable Motor Driven Cold Glue Mixers—2 to 15 gal. Glue Heaters for steam, electric or gas heat—2½ to 125 gal.; Portable Pot Glue Heaters.

COLD PRESSES

A wide line of high-production presses: Rotary-type; Air-Hose; Electric, Hydraulic and Hand Power Laminating Presses. Efficient, accurate, economical.

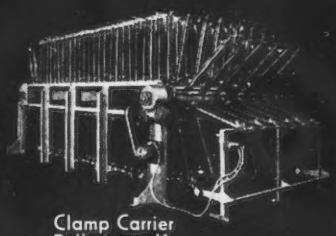
PRODUCTION CLAMPS

A production clamp for every need: Case Clamps—hand-powered or pneumatic, revolving or stationary; Clamp Carriers; Sash, Frame and Door Clamps.

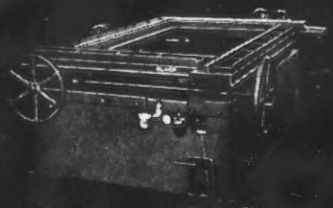
THE BLACK BROTHERS CO., INC.

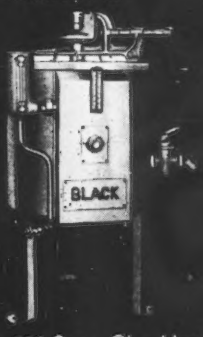
MENDOTA 8, ILLINOIS

Cold Glue Mixer
Bulletin 11-I

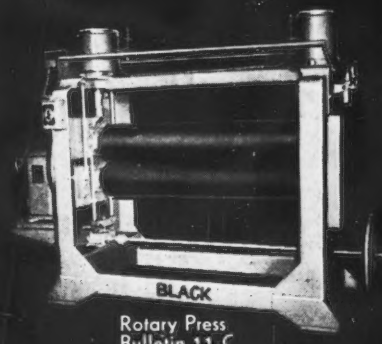

Clamp Carrier
Bulletin 11-K

Portable Glue Mixer
Bulletin 11-IS

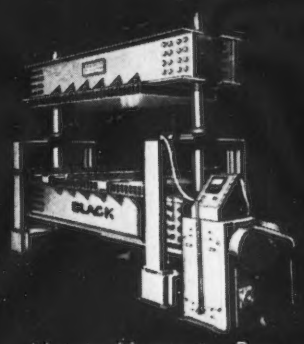

Sash, Frame and Door Clamp
Bulletin 11-M



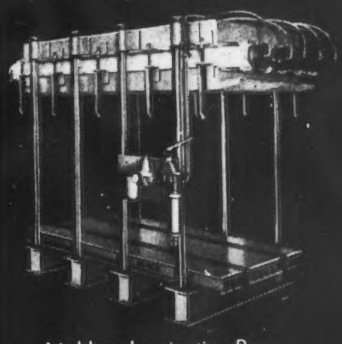
No. 700 Series Glue Heater
Bulletin 11-H



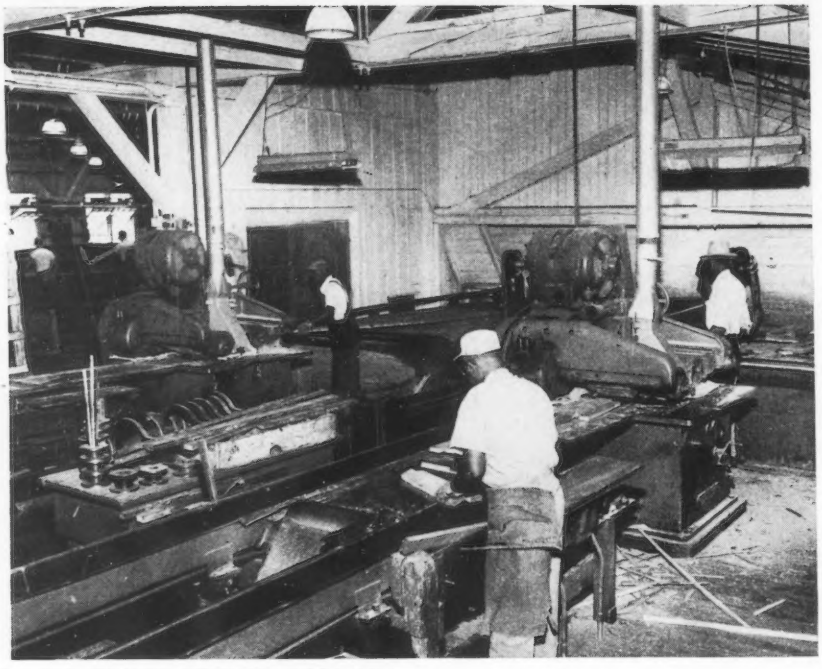
Rotary Press
Bulletin 11-C



Motorized Laminating Press
Bulletin 11-E


Air Hose Laminating Press
Bulletin 11-D

Announcement of Drake Tungsten-Carbide Saw Service For G-50 Gang Saws



NICKEY BROTHERS, INC.

Nickey Products Since 1866

Oak Flooring-Trim
Hardwood Lumber
Pres-to-logs
Hardwood Dimension

NICKEY BROTHERS INC. HARDWOOD PRODUCTS MORE BETTER MEMPHIS TENN.

Philippine Mahogany
Hardwood Plywood
Face Veneers
Rotary Veneers

LOCAL PLANT
2700 SUMMER AVE.
MEMPHIS 12, TENN.

September 9, 1959

Mr. C. E. Drake, President
Drake Corporation
3231 Sutton Avenue
St. Louis 17, Missouri

Dear Mr. Drake:

During the past several years, it has been our pleasure to have available Drake Saw Service in many phases of our operation.

The most recent service of this kind was in our flooring plant, with the conversion of our Yates-American G-50 gang rip saws to the Drake system. Using the Drake Saw Service on these machines provides us with the operation of saw blades 5/64" closer together. This combination of closer blades, thinner saw kerf and the elimination of saw tooth-marks, which would have to be machined out of strips, insures us a substantial increase in yield from lumber consumed by our flooring plant.

It is our sincere belief that by our use of Drake Saw Service, we have superior tooling and engineering at our disposal, resulting in a better yield from our material, labor and machinery at a lesser cost.

Very truly yours,

W. Jeter Eason
Executive Vice President

WJE:mj

IT IS WITH A GREAT FEELING of accomplishment that we announce the proven success of conversion of G-50 Gang Saw Machines for satisfactory usage of Drake Tungsten Carbide Saw Service.

Converted G-50's are now using Drake thin carbide saws at high feed rates in the manufacture of flooring.

For complete and specific information on the low cost of this Drake Service, send us serial numbers; age of your G-50 machine; the kind of feed rolls presently being used; whether the feed uses a separate motor or is driven by belt from the saw arbor; the h.p. and r.p.m. of the saw arbor motor.

Installation of Drake parts to convert the machine can usually be done by your own men over a weekend. A Drake engineer is available to instruct your men in making the changeover.

DRAKE CORPORATION

2723 Ivanhoe **St. Louis 39, Missouri**

ALE • HIGH POINT • SHAWANO • WEST MEMPHIS • KITCHENER • LA CHUTE • LANSDALE • HIGH POINT • SHAWANO • WEST MEMPHIS • KITCHENER • LA CHUTE • LANSD

The MARK of America's Finest Wood Glues

This Trade Mark is a familiar one to American Wood Workers for it identifies wood glues that have attained a standard of excellence often imitated but never duplicated.

Backed by almost 60 years of wood gluing experience and the most outstanding Gluing Service staff ever assembled in the industry, Perkins Glues are known to be consistently uniform in quality and dependability.

The result is that a Perkins Glued product is always a better product.

PERKINS GLUE COMPANY
Lansdale, Pennsylvania

LANSDALE • HIGH POINT • SHAWANO • WEST MEMPHIS • KITCHENER • LA CHUTE • LANSD

GREENLEE machines help White FURNITURE CO. maintain heirloom quality and high production...

The bedroom and dining pieces made by White Furniture Co. last for generations. They are masterpieces of stately beauty and fine craftsmanship, produced on Greenlee machines. In the White plant at Mebane, N. C., Greenlee Double-End Tenoners, Double-Spindle Shapers and Six-Roll Planers are in constant daily use. Plant officials are highly pleased with the performance of their Greenlee machines.

They are particularly pleased with the success they have had in cutting *solid* hardwood serpentine drawer fronts for the beautiful French Provincial Dresser at the right. This work is done on a Greenlee No. 545 Double-End Tenoner equipped with a dado attachment and lathe type cutterheads. The stock shown in the photo above is approximately 7½" wide by 36½" long. The company states that it could not achieve the same excellent production rate and smooth finish by any other means of machining.

Investigate the tremendous production potential of the versatile Greenlee Double-End Machines. Write for complete information.

WOODWORKING MACHINERY MANUFACTURERS' ASSOCIATION WMMA

GREENLEE BROS. & CO.

1711 TWENTY-FIRST AVE.
ROCKFORD, ILLINOIS

POTLATCH

for PRODUCT VARIETY

The Bradley-Southern Division of Potlatch Forests, Inc., offers a well-balanced assortment of lumber products manufactured to big mill standards of high quality.

MIXED CARS A SPECIALTY!

ARKANSAS SOFT PINE

Satin-like Interior Trim in
Casing · Base · Finish
Mouldings
Inside Door Frames
Wall Paneling
Planks · Boards · Shiplap
Finger-Jointed Stock
Lap and Drop Siding
Dimension · Sheathing

OAK SPECIALTIES

Stair Treads · Thresholds
Risers
Glued-Up Panels

OAK FLOORING

Unit Wood Blocks*
Straight-Line Strip
Random Width Plank
Finished or Pre-Finished
*Also in Beech and Pecan

FURNITURE DIMENSION

Our modern dimension plant offers dependable service on solid or glued factory material, fully machined and ready for assembly or semi-finished, moulded and tenoned to detail or cut to size in the rough.

Look To Potlatch ARKANSAS SOFT PINE REGISTERED **For** *Everything* **In Lumber**

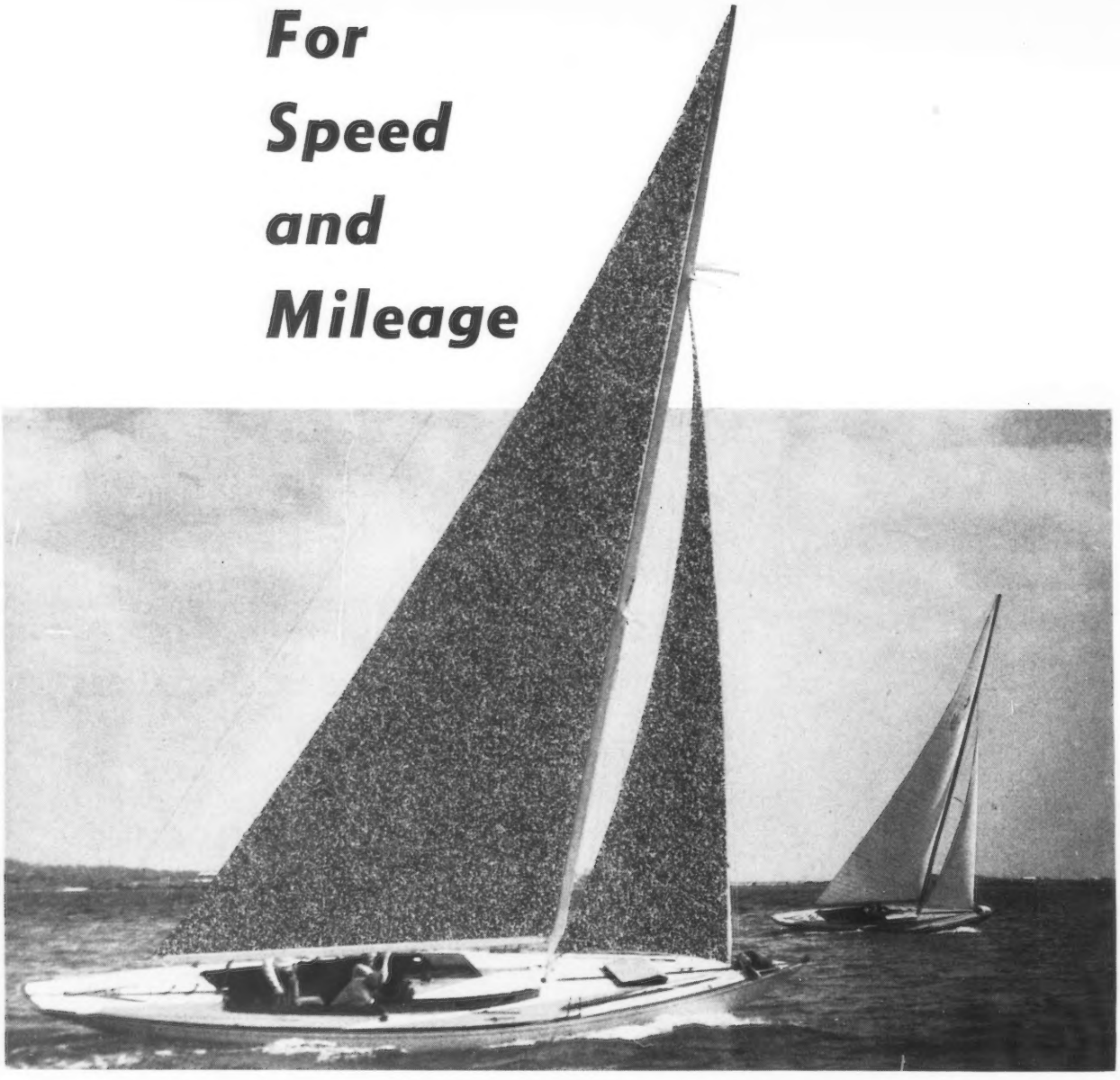
BRADLEY-SOUTHERN DIVISION

POTLATCH FORESTS, INC.

WARREN, ARKANSAS

Home of Famous Bradley Straight-Line Oak Flooring--None Finer!

For Speed and Mileage

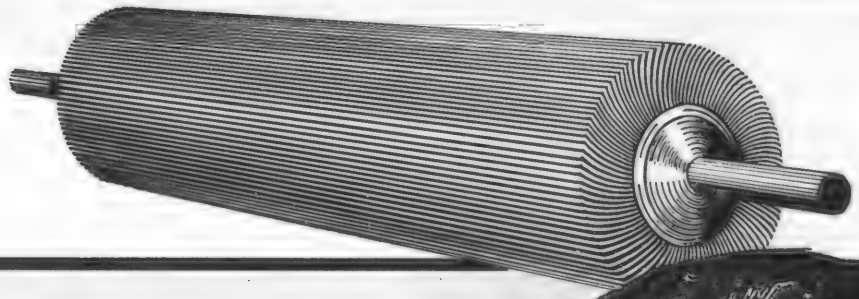


use Resinized ADALOX®

Now you can enjoy the benefits of faster production and more mileage per drum cover than you ever thought possible. Throughout the woodworking industry RESINIZED ADALOX Paper is setting new production records. Woodworker's favorite fast-cutting aluminum oxide grain is electro-coated and resin-bonded on high tensile E-weight paper, under expert technical control. Ask your BEHR-MANNING representative for a free demonstration of this remarkable RESINIZED ADALOX Paper.

BEHR-MANNING CO.
TROY, NEW YORK
A DIVISION OF NORTON COMPANY

BEHR-MANNING PRODUCTS: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes
NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals
In Canada: Behr-Manning (Canada) Ltd., Brantford. For Export: Norton Behr-Manning Overseas Inc., Troy, N. Y., U.S.A.



"The MERIT FLEX-DRUM SANDER *is one of the best investments we have ever made"*

says FRANK MARSHALL, *Gen. Mgr.*
PLYWOOD FINISHING CORP., *Brooklyn, N. Y.*

Sanding pre-finished plywood panels with the Flex-Drum Sander

Flex-Drum Sander can be fed manually or automatically

"We have a 50-inch Flex Drum Sander using #240 aluminum-oxide grit," he writes. "It has been used 8 hours a day ever since its installation in September 1958. Several million feet have passed through this sander unattended and without a single breakdown. *The original load of sandpaper is still in the unit.*

"It is used for sanding sealer and for burnishing lacquer topcoats on 4 x 8 foot plywood panels. We were the first to use this unit in our industry, and I feel that it was one of the best investments we have made, and we are considering purchasing another."

Plywood Finishing Corporation has taken the lead in the highly specialized pre-finished plywood industry. They have done it by automating their plant with the finest equipment and by eliminating hand methods. The Merit Flex-Drum Sander is an important part of this automated process and helps maintain high quality standards. Let us tell you how the Merit Flex-Drum Sander can be one of the best investments you can make, too. Write for Bulletin 79.

MERIT *Products Inc.* 3691 LENAWEE AVE., LOS ANGELES 16, CALIFORNIA

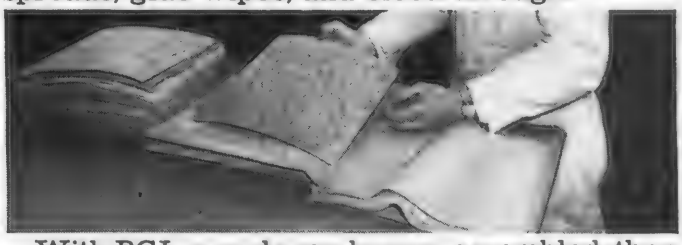
Manufacturers of SAND-O-FLEX and GRIND-O-FLEX abrasive tools

NOW—FROM REICHHOLD...

GLUE BY THE ROLL!

NEW WAY TO MAKE PLYWOOD WITHOUT GLUE ROOMS AND GLUE SPREADERS

PGL is the popular name for this new Reichhold product. That's short for "paper glue line." In effect, glue-by-the-roll, PGL consists of a cellulose carrier sheet impregnated with phenolic resin. You cut the sheet to size in the same way you do plastic overlay materials. Or you can use the continuous sheet as it is supplied for "automating" your plywood layup. In hot pressing, the resin remains on the glue line, where it's needed for maximum efficiency with minimum waste: eliminating uneven glue spreads, glue wipes, and bleed-through.



With PGL, panels can be pre-assembled, then pressed when convenient. PGL will tolerate higher moisture content veneers and hence help solve the age-old problem of blistering.

The potential of this modern glue-by-the-roll is tremendous. While film glues have been used sporadically for many years, Reichhold research has now come up with the basic improvements that were needed to make the product practical for standard plywood production. Reichhold PLYOPHEN PGL is faster curing, more economical.

Reichhold has successfully tested PLYOPHEN PGL in a wide variety of important bonding applications. If you would like detailed information on these applications, write to **Reichhold Chemicals, Inc., P.O. Box 3547, Seattle 24, Washington.**

Creative Chemistry ... Your Partner in Progress RCI

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol
Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Dust Control is a job for Engineers

The "rule of thumb" methods of the inexperienced, or the "engineering rules" of an experienced design, fabrication, and installation firm—which will you select for your dust control problems?

Kirk and Blum offers you . . .

ENGINEERING—a staff of qualified engineers with proven ability to solve your dust control problems.

RESEARCH—continuous research on full scale equipment, to develop the most efficient systems.

EXPERIENCE—over 50 years of dust control service to the woodworking industry.

Every Kirk & Blum installation is based on a complete service: Design — Fabrication — Installation, backed by K & B's acceptance of One Undivided Responsibility for the system to assure your satisfaction.

On your dust control problem consult Kirk and Blum, craftsmen in dust control for the woodworking industry, where fine craftsmanship is appreciated. The Kirk & Blum Manufacturing Company, 3231 Forrer St., Cincinnati 9, Ohio.

KIRK & BLUM DUST CONTROL SYSTEMS

Treatment on the 68-year-old Pier 3 was done by an Allied Chemical customer

68 years old— still sound! The true test of Creosote protection

Still sound—still useful.

High retention is the key to long-life service.

During dismantling of Pier 3 in the New York Harbor, 13 engineers specializing in waterfront structures inspected the piling which had been in service for 68 years. Their consensus? The piling was in remarkable condition and structurally sufficient for many more years of use.

During those 68 years, the piling was exposed to marine borers, but it showed no evidence of attack. Also, this piling was subjected to mechanical wear and abrasion from floating debris in the fluctuating tide zone, but due to the deep penetration of Allied Chemical Creosote, the piling was still sound and serviceable.

Surely, the testimonial of a good creosoted product is long-life protection. Here then, is living proof of the remarkable protective features which ALLIED CHEMICAL CREOSOTE can provide for *YOU!*

In addition, ALLIED CHEMICAL CREOSOTE features:

MULTIPLE TOXICITY: Marine borers, fungi and wood destroying insects cannot develop immunity to the many toxic agents in creosote.

PENETRATION EASILY CHECKED: You can see the depth of penetration in any cross-section.

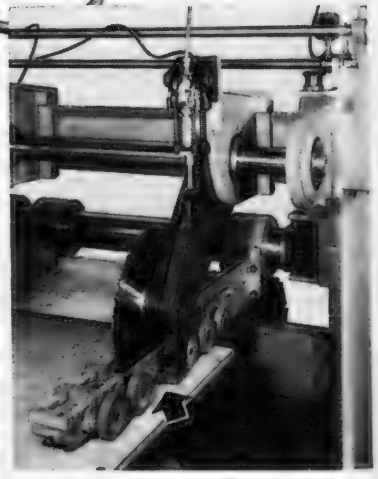
PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

NOW!
FINGER TIP CONTROL FOR SLAT BEDS

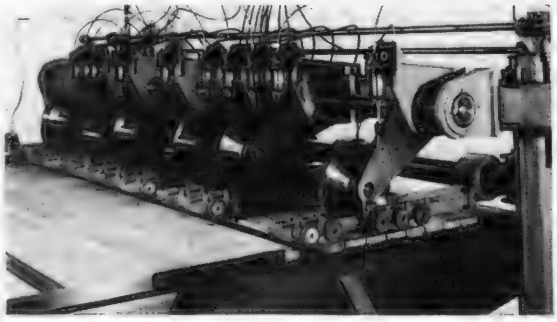
JENKINS *leads the way in modern production*

Precision — accuracy — superior performance — flexibility — yours with modern Jenkins woodworking equipment like the new slat bed pictured above. All these quality features have made Jenkins the pace-setter of the industry . . . and now the unique, new portable control panel that permits *finger tip control* of all power stations from any vantage point around the machine. Here's further proof that the best of fine woodworking machinery bears the Jenkins name.



Special roller bearing (arrow) adjusts to thickness of stock, assures consistent depth of cut regardless of surface irregularities. Rubber-wheeled holddowns remain in effective position when saw is lifted or removed for sharpening.

Ten saw-equipped Uni-Lifts on this slat bed allow operator to cut panels to any width needed. Multiple cutter set-up is also used for texturing. Quick response of Uni-Lifts plus finger-tip control permits panel width or surface texture pattern change at a flick of the finger while machine runs at production speeds.



JENKINS DEALERS: James Murphy, Cambridge, Mass; H C Whitlock Corp, NYC, N Y; Dimension Mill Eqmt Co, Deansboro, N Y; H W Krehnbrink, Baltimore, Md; Garrison Mach Co, Statesville, N C; Hottson Mach Co, Dayton, Ohio; Palmer Mach Co, Jacksonville, Fla; Tom Clancy, Detroit, Mich; Green Mach Co, Chicago, Ill; Evan Kroll, Peru, Ind; Wm Page, Oliver Mach Co, Memphis, Tenn; Jack Flanders, Little Rock, Ark; Tri-State Mach Co, Dallas, Tex; Cascade Saw & Mach Co, Chehalis, Wash; Hall Mach Co, San Jose, Cal; Jenness Mach Co, Los Angeles, Cal; Upton Bradeen & James Ltd, Toronto, Ont, Can.

ENGINEERED AND BUILT BY **KJ** KOHLER-JOA CORP., SHEBOYGAN FALLS, WISCONSIN

RESIN ADHESIVES by Catalin

. . . set the highest standards for QUALITY, ECONOMY and UNIFORMITY

• UREAS

formula	type	solids	use	for specs
802	liquid	46%	hot & cold press	AN-G-8, MMM-A-188, CS35-56
804	liquid	51%	hot & cold press	AN-G-8, MMM-A-188, CS35-56
813	liquid	65%	hot & cold press	AN-G-8, MMM-A-188, CS35-56
825	liquid	60%	hot & cold press	AN-G-8, MMM-A-188, CS35-56

• MODIFIED UREAS

formula	type	solids	use	for specs
IMPROVED WATER RESISTANT				
8690	liquid	60%	hot & cold press	MMM-A-188, CS35-56
CRAZE RESISTANT TYPE				
8686	liquid	50%	intermediate & cold press	MMM-A-188, CS35-56

• RESORCINOLS

formula	type	solids	use	for specs
728	liquid	57%	hot & cold press	MIL-A-397B
731	liquid	55%	hot & cold press	MIL-A-397B
736	liquid	56%	hot & cold press	MIL-A-397B

• PHENOLICS

formula	type	solids	description
9068	liquid	66%	Fast-curing water-soluble resin for particle board.
9297	powder	—	Fast-curing resin for increased flexural strength and moisture resistance, used for molded shapes of wood flour and particle board.

Since the introduction of resin adhesives, a little more than a quarter-century ago, Catalin's ability to develop and deliver the most modern types of resin with absolute uniformity . . . batch after batch . . . month after month . . . has won the highest regard of woodworking production personnel.

The versatile adhesives listed here, together with Catalin-developed accelerators, because they establish superlative levels of dependability, quality and economy, have found wide acceptance for both hot and cold press woodworking operations and products. Catalin field representatives are qualified to assist you in adapting these formulations to your specific requirements.

Fast deliveries from three strategically located plants in the East, Midwest and South — Fords, N. J., Calumet City, Ill., and Thomasville, N. C. — are a feature of Catalin's unsurpassed service.

Write for your free copy of "Catalin Adhesives," which describes all the types Catalin produces and contains a special section of practical hints on the successful use of urea resin adhesives.

CATALIN CORPORATION OF AMERICA
ONE PARK AVENUE • NEW YORK 16, N. Y.
— Plants —
Fords, N. J. • Calumet City, Ill. • Thomasville, N. C.

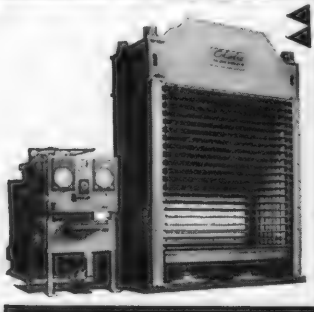
. . . for time and money saving production of

pick a

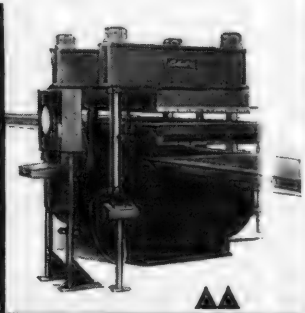
TIME-PROVED INDUSTRY-APPROVED

Columbia

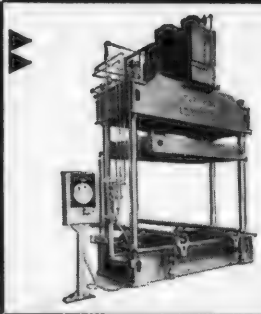
HYDRAULIC PRESS



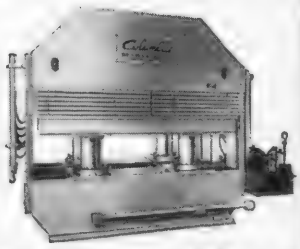
HOT PLATE PRESSES . . . 15 outstanding features for top production and quality, saving time and money. Rigid design, trouble free hydraulic system and honest rating guarantee dependable performance. Request Bulletin HP-300.



COLD LAMINATING PRESSES . . . proved for low-cost operation. Available in a complete range of sizes and types, upstroke and downstroke models, pressures to 200 psi. Convertible to high frequency operation. Request Bulletin HP-200.



SHUTTLE PRESSES . . . designed and pioneered by Columbia to utilize labor to the fullest extent. Handlers discharge and reload one caul while load on other is under compression in the press. Request Bulletin HP-400.



HIGH FREQUENCY PRESSES . . . double duty: cold laminating or with high frequency heating for fast production of large or small lots with low-cost, shop-made forms for better curved laminated panels. Request Bulletin HP-300.

FLOOR TYPE PRESSES . . . offering one to five daylights and economy of installation and operation. Feature most advanced hydraulic and mechanical equipment. Available in end and side-loading models. Request Bulletin HP-400.

Columbia Hot Plate, Cold Laminating and High Frequency Presses incorporate modern, proven features which assure production output, quality and efficiency with trouble-free performance. Their industry-wide acceptance is the result of many years of experience in design and manufacture of presses.

For detailed COLUMBIA literature, write:

The LODGE & SHIPLEY Company

3063 Colerain Ave., Cincinnati 25, Ohio

Our Research Today . . .
for Your Progress Tomorrow

How has American-Marietta researched for profit? Since 1941 costs of manufacturing phenolic resins have risen steeply – raw material costs are up 50%, authorized freight rates are up 120%, and labor costs are up 150%. Yet by increasing product efficiency, broadening product applications, manufacturing in greater volume, and improving packaging methods, we can now deliver exterior phenolic resin to your plants at a lower price than that which prevailed in 1941.

Of even greater significance, since 1941 the average cost of your exterior glue line has been reduced 24%. This lower cost to you is the result of American-Marietta's diligent research and service which has improved the resin as well as the methods of converting it into a reliable, durable adhesive.

AMERICAN-MARIETTA COMPANY

SEATTLE, WASHINGTON • NEWARK, OHIO

ADHESIVES & SYNTHETIC RESINS FOR—

PLYWOOD
COMPOSITION BOARDS
WET STRENGTH PAPER
MINERAL WOOL
FOUNDRY CORES & SHELL MOLDS

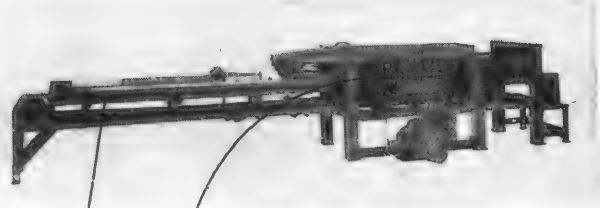
NOW...

An "in-line" continuous feed Electronic Finger Joint End-Gluer. Completely cures adhesives at high speeds better and faster than any previous method.

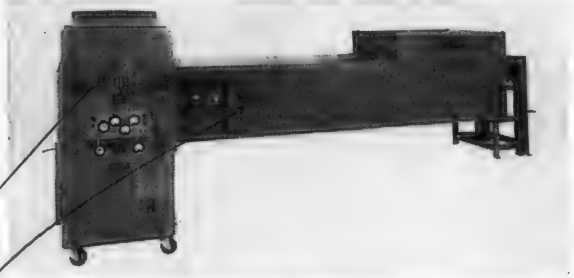
Mann-Russell Electronic

Continuous FINGER JOINT END-GLUER

- ★ AUTOMATED straight line operation . . . no side transfer of material until after glued and sawn to length.
- ★ Traveling cut-off saw adjustable for any length of stock.
- ★ Most economical method of recovery of shorts, waste material or degrade.

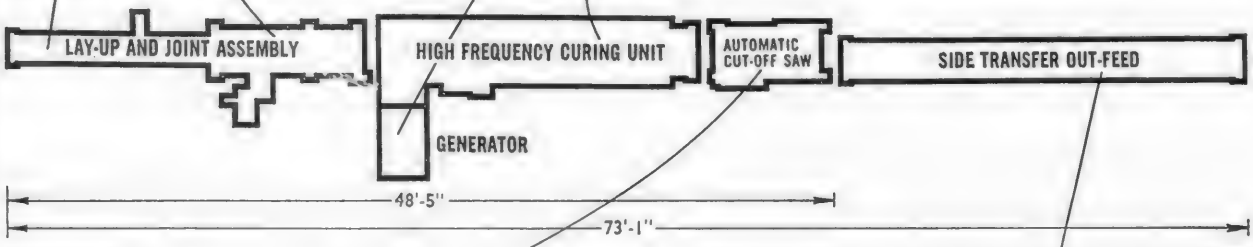


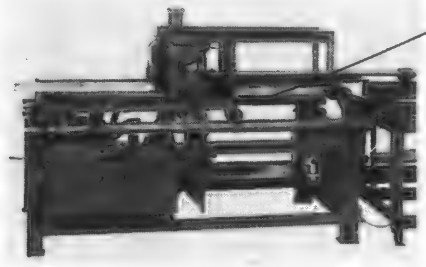
LAY-UP AND JOINT ASSEMBLY UNIT V-belt drive and positive retard assures tight fitting of finger joints before entering curing unit.



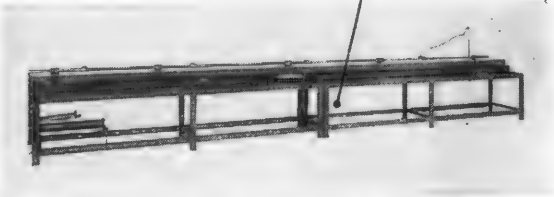
GENERATOR AND STANDARD HIGH FREQUENCY CURING UNIT. Mann-Russell Model 700 Generator and Electrode section. New patented electrode, adjustable from 3 through 12 inches to 8/4 thick stock. Other sizes special order.

FLOOR PLAN LAYOUT





AUTOMATIC TRAVELING CUT-OFF SAW UNIT. Quickly and automatically cuts stock to desired length as it leaves curing unit.



SIDE TRANSFER OUT-FEED TABLE UNIT. Optional equipment custom built to length and with air ejection or belt side transfer.

Complete details available from . . .

MANN-RUSSELL ELECTRONICS

SO. 23rd & PACIFIC AVE., TACOMA 2, WASH.

Phone: FUlton 3-1593

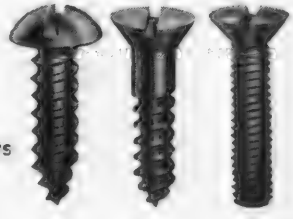
IN FASTENERS SOUTHERN IS the source

Southern has many customers who know that for every screw requirement, Southern is the source "from which all fine fasteners flow." Southern is proud of being recognized as the source for customers who order and receive screws of highest quality, on time, and at a fair price.

If you haven't tried Southern as the source for your requirements, one order will convince you that you've been missing something. Write for Southern's current Stock List. Address: Southern Screw Company, P. O. Box 1360, Statesville, North Carolina.

Manufacturing and Main Stock in Statesville, North Carolina
Warehouses: New York • Chicago • Dallas
Los Angeles

Wood Screws
Dowel Screws
Hanger Bolts
Drive Screws
Carriage Bolts
Machine Screws & Nuts
Tapping Screws
Stove Bolts



Let National Casein help you PROLONG THE LIFE OF YOUR WOOD PRODUCTS

Woodtrol (WRP)

water repellent preservative protects wood from destructive insects, rot and stain . . . imparts water repellency to wood.

Woodtrol (WRL)

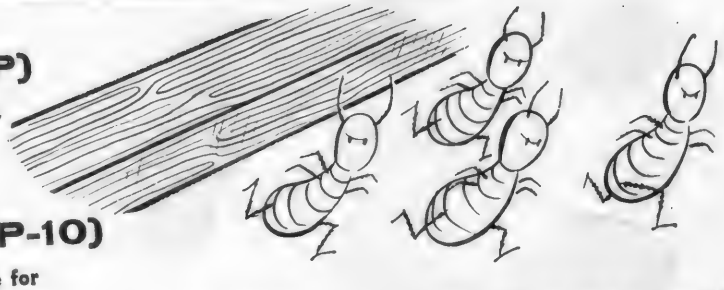
water repellent lubricant reduces friction between moving wood parts and makes wood water repellent.

Woodtrol (P)

preservative for millwork, furniture and structural lumber.

Woodtrol (P-10)

Woodtrol (P) concentrate for large quantity users.



"That lumber's too highly seasoned for us!"

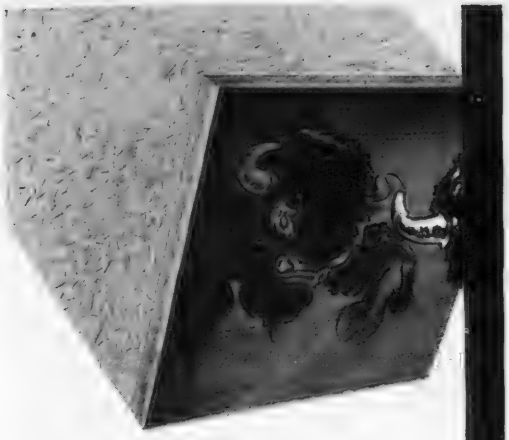
YOUR "NATIONAL CASEIN" GLUE MAN HAS NEWS FOR YOU

In addition to helping you determine the right glue for your job—the "National Casein" man who calls on you is now equipped to help you protect your wood products against deterioration from mechanical wear, moisture, mildew, rot, stain and from insects. "National Casein's" Woodtrol series of wood protectors is helping the furniture, millwork and structural lumber industries to prolong the life, beauty and usefulness of their wood products and wood construction. Write for data, prices, samples. Ask the "National Casein" man who calls on you about Woodtrol wood protection, or contact the office nearest you. No obligation to purchase.

National Casein

National Casein Company, 601 W. 80th Street, Chicago 20, Illinois and Tyler, Texas

National Casein of New Jersey, Broad & Fulton Streets, Riverton, New Jersey

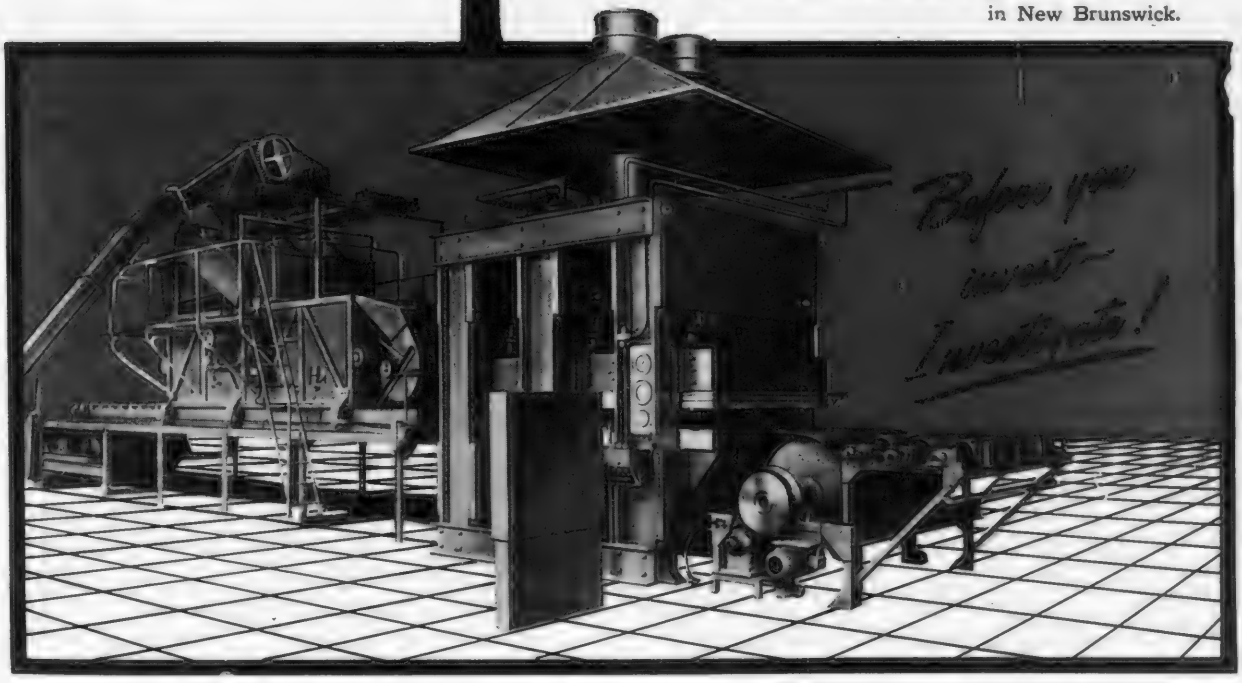


More than 30* successful installations now in operation throughout the world prove the superiority of the

Bison System

- **Producing the world's finest flakeboard even when using planing mill shavings**
- **Semi-automatic operation**
- **Lowest installation and production costs per daily ton**
- **Exclusive single opening press installation and versatile multiple-press installation**

*A multiple-press 110,000 bft mill is now being installed at Albany, Oregon, and a single-opening press in New Brunswick.



World-famous Bison Board offers many exclusive features worth your investigation — superior finishing and machining qualities inherent in its "graduated three layer" structure; lower finished product cost through savings in raw materials, as this is the only system that can produce a high quality board with 3500 M.O.R. when using 75% shavings.

Also investigate the exclusive glue mixing machine, lowering high cost for resins in making boards of high strength and screw-holding properties.

Every Bison System installation is test-run and proved before shipment, eliminating costly mistakes and start-ups. We can supply flakeboard *made from your own raw materials* run through a standard production plant in advance of order and without obligation. See us for details.

Films and literature available. Call, wire or write:

Sole American Distributor:

SODERHAMN MACHINE MANUFACTURING COMPANY

Talladega, Alabama

West Coast: 9442 S.W. Barbur Blvd., Portland, Oregon

SUMNER CHIPPERS

for every purpose

53" — 4 Knife Economy Chipper — Designed for the lower production installation where a high capacity machine is not necessary. Slabs up to 19" wide and 8" thick can be chipped by this light, well-built machine. Ask for Bulletin #85.

The widely heralded program of complete wood utilization launched a few years ago, presented its challenge to us here at Sumner, and led us into an ever broadening field of chipper research, engineering, and manufacturing of this most important piece of production machinery.
Our present line of chippers and chip screens speaks well for our progress in this field . . . you will find our Sales, Research, and Engineering Staffs more than anxious to work out any specific problems you may have and to furnish you with bulletins and additional information covering our present standard or special models.

66" — 16 Knife, Helicoidal Face, Wastewood Chipper — The wear (face) plates are provided with helicoidal surfaces which set up an "auger action" that pulls the wood toward the disc in a smooth, uninterrupted flow, thus maintaining an exact chip length. This precision built machine, also available in the 53" size offers you the "utmost" in production and quality. Ask for Bulletin #78.

Designers and Builders of

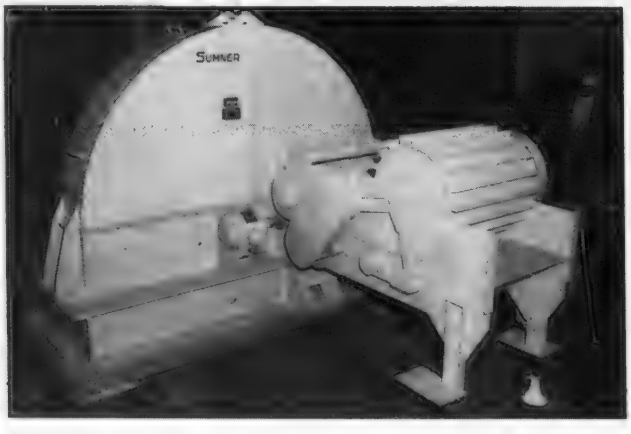
Log Handling Machinery

Wood Room Machinery

Sawmill Machinery

Briquettors

Steel, Iron and Bronze Castings



72" — 6 Knife Vertical Cut Veneer Chipper — Utilizing the latest designed feedworks, it is the answer to the operator's demand for volume output of chips with minimum operational costs. Ask for our Bulletin #83.

SUMNER IRON WORKS

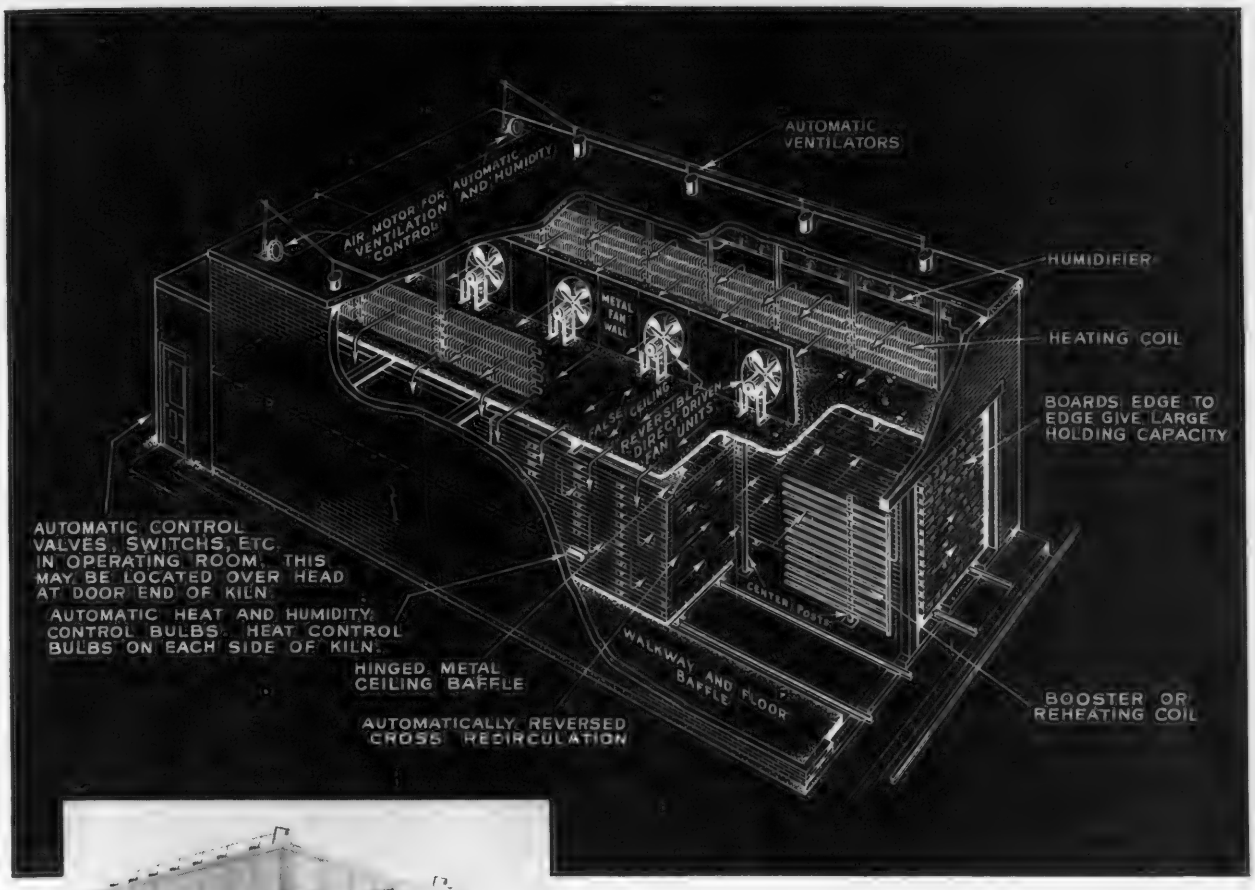
EVERETT, WASHINGTON

Since 1892

In Canada: CANADIAN SUMNER IRON WORKS, LTD., Vancouver

DESIGNERS AND BUILDERS OF MACHINERY FOR THE FOREST PRODUCTS INDUSTRIES.

United States Distributors: FRED E. BARNETT CO. . . . 5 offices in California and Oregon . . . WILCO MACHINE WORKS, INC. . . . Memphis, Tennessee . . . . . DILLON SUPPLY CO. . . . . Raleigh, North Carolina.


AUTOMATIC VENTILATORS
AIR MOTOR FOR AUTOMATIC VENTILATION AND HUMIDITY CONTROL
HUMIDIFIER
METAL FAN WALL
HEATING COIL
FALSE CEILING
REVERSIBLE DIRECT DRIVEN FAN UNITS
BOARDS EDGE TO EDGE GIVE LARGE HOLDING CAPACITY
AUTOMATIC CONTROL VALVES, SWITCHS, ETC. IN OPERATING ROOM. THIS MAY BE LOCATED OVER HEAD AT DOOR END OF KILN.
AUTOMATIC HEAT AND HUMIDITY CONTROL BULBS. HEAT CONTROL BULBS ON EACH SIDE OF KILN.
CENTER POSTS
WALKWAY AND FLOOR BAFFLE
HINGED METAL CEILING BAFFLE
AUTOMATICALLY REVERSED CROSS RECIRCULATION
BOOSTER OR REHEATING COIL

Before you O.K. any plans for dry kilns...get the STANDARD story

• Get the Standard story now—because it may pay your company dividends for years and years to come. See how Standard's 72 years of specialization assures you the highest quality engineering and manufacturing. Ask owners about Standard's reputation for integrity . . . how Standard solidly backs the quality and workmanship of every Standard Dry Kiln. Have your secretary write or tear out this advertisement and mail it today with your name, company and address for the complete Standard story.

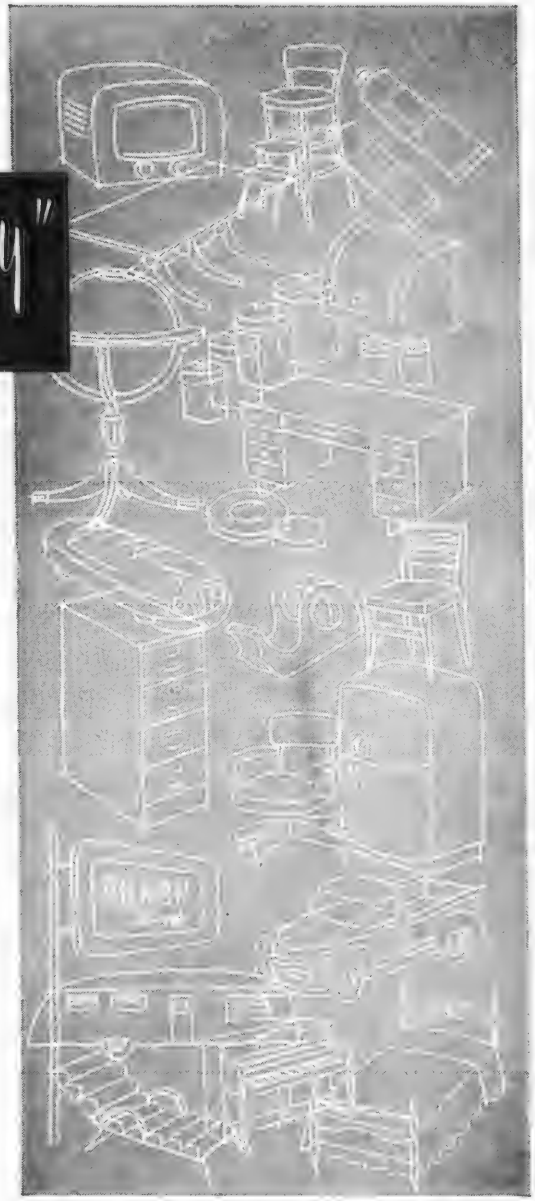
Irvington MACHINE WORKS

WESTERN STATES REPRESENTATIVE FOR

STANDARD DRY KILNS

IRVINGTON MACHINE WORKS • 1808 N.E. 7TH AVENUE, PORTLAND 12, OREGON • ATLANTIC 4-1187

"Coatings by Lilly"



Whatever the product—
whether it be
METAL...WOOD...PLASTIC
or PAPER—there's a
Lilly coating made to fill
the finishing requirements
of manufacturers' individual
needs. Development of
coatings for specific use
is an important part
of the technical services
designed by Lilly to help
industry in the field of
finishing. Contact your
nearest Lilly plant.

LILLY **VARNISH COMPANY** • **Indianapolis, Indiana**

AFFILIATED PLANTS / LILLY VARNISH OF MASSACHUSETTS, GARDNER, MASS.
THE LILLY COMPANY, HIGH POINT, N. CAROLINA
PRODUCTOS AUROLIN, S. A., MEXICO CITY

"Choosing the Best Paths"

Departing remarks of President W. J. Eason, at Official Luncheon, FPRS 13th National Meeting, San Francisco, June 30, 1959.

In the past year a number of controversial and serious problems concerning basic policy have arisen within FPRS. Your Board has had to face them; and some were not without merit. Much has been written and said by many interested and sincere parties. As your President, I have written many letters and made thirteen trips to regional, sectional, and board meetings, to learn the feelings of our members in various parts of the country, who represent a wide variety of interests and opinions. I strived also to convey the work, as of these times, that the Board was carrying on.

A Welcome Challenge

I wish to emphasize that your Board has never resented the many problems encountered or the oftimes contradictory positions of qualified and sincere spokesmen. Rather, it has taken these as a challenge to do a better job for the members at large.

Our Society, now 13 years old, is not by most standards an old society. We are, comparatively, in the adolescent stage, arriving at a time in our existence when many attractive routes and temptations are open. But these avenues must be carefully examined and chosen, so that when we one day reach full maturity we shall feel confident in the knowledge that the paths we have chosen have been the best ones.

In the course of our discussions of changes, it has at times been erroneously construed that changes in operation had been approved that would effect a wide departure from precedent; changes that many thought were detrimental and that others thought would be for the improvement of the Society. These particular changes have not been put into effect; however, due consideration to all proposals offered ostensibly for the betterment of the Society will always be considered by your Board.

Dedicated Leadership

Many of our members have written to let us know their thinking, and for this we thank you. Your opinions are highly valued, and will continue to be our guide for the future to the end that our paths will not be aberrant to the goals set by our founders.

What I have said simply leads to the fact that the magnitude of the problems that have arisen in the past year is such that these problems will carry into the next, and possibly future years. The good news in all of this lies in the fact that our members have, continuing, the highest possible category of leadership.

It is my pleasure and honor to introduce a man whom most of you already know—"Scotty" Harrar. Eminently qualified by training, a man of sympathetic and aggressive interests, and one living, as Dean of the School of Forestry of Duke University, in an environment of dedicated purpose. Scotty will assume active office as your President upon the close of this annual meeting. From then until the close of the next annual convention at Montreal, where he will stand where I am now, he will be the captain of the ship of FPRS.

FPRS News-Digest

Southeastern Section to Meet at Daytona Beach, Florida, Dec. 3 and 4

By popular demand the Southeastern Section is again holding its 1959 meeting at Daytona Beach, Florida, on December 3 and 4. The meeting will be held at the Daytona Plaza, a large modern hotel on the waterfront.

"DEVELOPMENTS IN THE FOREST PRODUCTS INDUSTRY"

December 3—10:00 A.M.—Noon—Registration

1:30 P.M.—PULP AND PAPER, Presiding: William L. Belvin, Director, Herty Foundation, Savannah, Georgia

1. "The Availability and Use of Some Hardwoods"—P. W. Chestnolvick, Forest Economist, International Paper Company, Mobile, Alabama.
2. "Closer Utilization—Key to Efficient Pulpwood Production"—J. A. Holekamp, Forest Engineer, American Pulpwood Association, Sylacauga, Alabama.
3. "Hardwoods for Pulping Purposes"—J. H. Ainsworth, Vice-President, Noralyn Paper Mills, Inc., Baton Rouge, Louisiana.
4. Panel Discussion: William L. Belvin, Moderator; P. W. Chestnolvick; J. A. Holekamp; J. H. Ainsworth; Ralph B. Parker, Pilot Plant Superintendent, Herty Foundation, Savannah, Georgia.

4:30 P.M.—Business Meeting; 6:00–7:00 P.M.—Social Hour; 7:00 P.M.—Banquet

December 4—9:00 A.M.—FINISHES AND PLYWOOD, Presiding: Reland B. Westgate, Plant Manager, Georgia-Pacific Corporation, Savannah, Georgia.

1. "Printing Plywood"—Mr. Joe Thiel, American Marietta Corporation, Kankakee, Illinois.
2. "Finishing Wood"—Mr. Hoyt Bray, President, Reliance Varnish Company, High Point, North Carolina.
3. "Plastic-Plywood Laminate"—Mr. Bernard Hewitt, Chairman, Industrial Plywood Company, Inc., Jamaica, New York.

1:30 P.M.—RESIDUE UTILIZATION, Presiding: Rufus H. Page, Technologist, Southeastern Forest Experiment Station, Asheville, North Carolina.

1. "Continuous Carbonization of Fine Residue"—Mr. E. E. Dargan, President. Charcoal Industries, Inc., Conway, South Carolina.
2. "Unitized Parquet Flooring"—Mr. Ralph Peter, U.S. Forest Service, Athens, Georgia.
3. "Background and Development of a Chip-Producing Saw"—Bill Briggs, Simonds Saw and Steel Company, Fitchburg, Massachusetts.
4. "Economic Implications of Chip-Producing Saws"—Parks Brewer, Chip Procurement Supervisor, Buckeye Cellulose Corporation, Foley, Florida.
5. Panel Discussion: Rufus H. Page, Moderator; Bill Briggs, Parks Brewer; Jake Griffin, Wells-Griffin Lumber Company, Valdosta, Georgia; Lawton Holland, Simonds Saw and Steel Company, McRae, Georgia.

Important FPRS Dates

December 3–4, 1959: Southeastern Section Meeting, Daytona Beach, Florida.
February 8–9, 1960: Northwestern Section Meeting, Bellingham, Wash.
March 24–25, 1960: Northeastern Section Meeting, Hartford, Conn.
June 5–9, 1960: Fourteenth National Meeting, Montreal, Canada.

Russia Behind On Forest Research Reports Dean Garratt

The Soviet Union is lagging behind the United States in both quantity and quality of wood products, Dean George A. Garratt, Yale School of Forestry, and a member of a seven-man team that toured forestry schools, wood-products plants, and the forests of Russia reported.

Wood production is being speeded under a seven-year plan, but "the progress to date appears to be in the area of mechanization rather than in the technology of wood use. As a result, improvements in quality of wood products in the Soviet Union are not nearly so striking as the increases in quantity. In several wood-product plants, the processing appeared plagued with outdated design, backward methods of production, antiquated and inadequate machinery, and low quality of the production.

The forests of the U.S.S.R. cover some 2,827,000,000 acres, as compared to 784,000,000 acres in the United States. But most of the Russian forests are softwoods, and its hardwood stands are much less than American, both in extent and in diversity of species.

Russia produced 34 billion board feet of sawed lumber in 1958, as against American production of close to 40 billion board feet. Production goals in Russia call for a marked increase in virtually all categories of wood products. In contrast to the expected 1959 manufacture of prefabri-

cated houses in the equivalent of 107 million square feet of floor space, the Soviet sawmills have a goal of three times this output by 1962.

In research, the Americans found a definite dearth of fundamental investigative work, even in the strictly research institutions, where the staffs were devoting their attention primarily to studies of an applied nature. In fact, the American team saw little effective research in the forest science field, other than in areas related to mechanization. One of the most striking observations was the general lack of greenhouses at both educational and research institutions, Dr. Garratt concluded.

Work Injuries and Injury Rates in Sawmills And Planing Mills

The U. S. Department of Labor, Bureau of Labor Statistics recently issued the final report on the Bureau's study of work injuries in sawmills and planing mills.

The 33-page report shows that the lumber industry has had considerable success in reducing the work-injury frequency rate in the postwar years, but there is still room for considerable improvement.

In 1946, sawmills had a work-injury frequency of 64.1 by 1957 this rate had dropped to 45.0. Planing mills, which had a frequency rate of 35.1 in 1946, were down to 30.2 in 1957.

These were noteworthy improvements, but they did not match the general reductions achieved throughout manufacturing during the same period.

The information contained in this report is intended to stimulate accident-prevention efforts in industries with high injury-frequencies and encourage continuance of such activities in those with low rates.

Data included in the report show the estimated cost of work injuries, the kinds of injuries experienced, and comparisons on a geographic, size-of-mill, and departmental basis.

Single copies of the booklet, BLS Report No. 146, "Work Injuries and Work Injury Rates in Sawmills and Planing Mills," are available on request to the Bureau of Labor Statistics, U. S. Department of Labor.

J. J. Fitzpatrick Lumber Co. Erects Madison Warehouse of Fire-Retardant Douglas Fir

The J. J. Fitzpatrick Lumber Co., Madison, Wis., recently erected the first wood-frame industrial building in Madison with more than 10,000 square feet of floor areas.

Code requirements of the new warehouse, which covers 13,000 square feet, were met by using beams and roof trusses of fire-retardant treated Douglas Fir supported by southern pine poles.

The structure has been so successful, the company is considering building a plant to treat wood with preservatives and fire-retardant chemicals, according to L. J. Fitzpatrick, company president.

Production of Bituminized Fiber Sewer and Drain Pipe

Production of bituminized fiber sewer and drain pipe by the nation's 8 manufacturers, operating 11 plants, aggregated 75,680,000 lineal feet in 1957 according to a survey recently conducted by the Building Materials Division of the Business and Defense Services Administration. Some 67,596,000 lineal feet of this production was 4-inch pipe. In addition, the survey indicated that during 1957 the industry produced 12,202,000 fittings, 10,200,000 of which were couplings. The balance of the fittings consisted of adapters, elbows, tees, and wyes. Cast iron soil pipe fittings are also generally used in connection with the installation of bituminized fiber pipe. The production figures do not include conduits which are also produced in the same plants but which have thin walls.

The survey showed that, although bituminized fiber is produced in all except one region of the United States, the greatest production is in the states of New Hampshire, New York, and Texas. Two new plants are presently under construction at Landisville, New Jersey, and Birmingham, Alabama.

Army Tests Electro-Kiln For Drying Gunstock Blanks

The Army Ordnance Corps has experimented with the new electro-kiln method of drying lumber with good results on black walnut gunstock blanks, according to a report just released by the Office of Technical Services, U. S. Department of Commerce.

Gunstock blanks were dried from a moisture range of 10 to 14 percent to a range of 4 to 6 percent in only a few hours, as compared to 14 days by conventional methods.

In this method of kiln drying, power is supplied by a radio frequency generator, and the heat radiates outward from the core of the wood driving the internal moisture before it to the surface. The temperature of the wood and the kiln can be rapidly established and maintained or controlled to suit the requirements of the wood in process.

The report of these tests, PB 151301 may be ordered from OTS, U.S. Department of Commerce, price 50 cents.

"Wood Award Competition" Announced for 1960

The annual "Wood Award Competition" will be held again in 1960, according to a joint announcement by Everett Ellis, Chairman of the FPRS Industry–Education Division, and J. F. Koellisch, Editor and Manager of Wood and Wood Products Magazine.

The competition, which has been sponsored jointly for the past 11 years by the Society and Wood and Wood Products Magazine, is open to graduate students who were or are attending school between January 1, 1959 and April 30, 1960.

A $350 cash award will be granted the first-ranking research paper submitted, and a $150 award will go to the second-ranking graduate paper.

The joint announcement stated that tentative titles must be submitted by March 1, 1960 to the: Executive Secretary, Forest Products Research Society 417 North Walnut St., Madison.

Additional information on the contest can be obtained by writing the National Office of the Society.

Koppers to Build Alaskan Wood Treating Plant

Koppers Company, Inc., will build and operate the first wood preserving plant in the 49th State—Alaska—according to Douglas Grymes, Jr., vice president and general manager of Koppers Wood Preserving Division.

Grymes said his Division has started to build a plant at Whittier. The property was leased from the Alaska Railroad, and it is adjacent to the Columbia Lumber Co.

It is anticipated that the plant will be operating by July 1960.

DFPA Seeks Men to Expand Field Force

The Douglas Fir Plywood Association plans a substantial expansion of its field promotion force in 1960, according to S. A. Taylor, field promotion director.

The present force includes 60 men who provide specification assistance to architects, engineers, builders, contractors, and other volume plywood users. The expansion will add 19 more men to the field force.

The projected expansion reflects the growth of the western fir plywood industry in recent years.

Softwood plywood production will probably top seven billion square feet this year, and it will increase again next year. This growth pattern requires increases in field personnel throughout the United States, Taylor said. Qualified men should contact Taylor at DFPA's Tacoma, Wash., office.

100 Attend Adhesives Institute Co-sponsored by Gluing Division and University of Wisconsin

The Glues and Gluing Division of the Forest Products Research Society, in cooperation with the Engineering Institutes of the University of Wisconsin and the U. S. Forest Products Laboratory, conducted the first symposium on Industrial Adhesives Application held at the University.

About 100 industrialists and technologists from all over the U.S. attended the two-day session, which was held October 1–2 at the University's new Wisconsin Center Building. Those attending evaluated the meeting in two words "Extremely successful."

The two-day program consisted of 12 speakers from industry and the U.S. Forest Products Laboratory. General topics covered included "Designing with Adhesives," "Adhesives in the Wood and Paper Industries," "Adhesive Fabrication of Metals and Plastics," Quality Control Problems in Adhesive Bonding," "the Future for Future Adhesives," New Glued Wood Products," and Trouble Shooting Adhesive Bonds."

The general topics were broken down into specific sections that discussed the use of adhesives in plywood and doors, laminated timber, particle board, paper and fiberboard, metals and plastics, and new glued wood products.

The formal sessions were followed by discussion period in which the speakers acted as a "brain trust" and answered questions concerning conferees specific problems.

Executive Secretary Frank J. Rovsek presented the welcoming address, and Richard F. Blomquist, Chairman of the Glues and Gluing Division, presided at the first day's session.

Others who took part in the meeting included Al J. Slosser, Armstrong Cork Co.; Leonard A. Ropella, Roddis Plywood; Maurice J. Ruhde, Unit Structures Inc.; Willard J. Worth, National Homes Corp.; John W. Maxwell, The Borden Chemical Co.; Richard E. Smith, H. B. Fuller Co.; Robert L. Loetscher, University of Wisconsin; Robert Stedfeld, Machine Design; Clayton O. Stevens, Kawneer Co.; Robert Zins, Rubber and Asbestos Corp.; Charles Latimer, Nickey Brothers, Inc.; G. W. Grain, Minnesota Mining and Manufacturing; and Bruce Heebink, U. S. Forest Products Laboratory.

NLMA Opens New Field Office In Dallas, Tex.

Robert F. Goodney, 35, former field supervisor of sales for Darworth, Inc., manufacturer of wood preservatives and building specialties, has been appointed regional manager of a new technical promotion field office to be opened in Dallas, Tex., on Nov. 1. Covering a seven-state area, Goodney will work with builders, arhcitects, engineers and designers to encourage greater use of lumber and wood products in all classes of construction.

Noralyn Paper Mills, Inc. Produce Hardwood Newsprint On a Commercial Scale

Noralyn Paper Mills, Inc., of Baton Rouge, La., recently culminated a research project began in 1958 by converting a pilot plant operation to a commercial mill capable of producing 350 tons of newsprint a day, without using one single pound of coniferous fibers.

The sheet produced is brighter than standard newsprint, having a photovolt brightness of 65 to 67 points. It also has printing quality and runability that have been praised by some of the Nation's leading newspapers.

Last July, Noralyn entered an agreement with the H. K. Kerguson Co. of Cleveland, Ohio for final design and construction of a plant to produce 350 tons newsprint a day. The new plant is located at Busche, La.

Northeast Ohio Machine Builders Acquire Counsel Manufacturing Resaw and Bandmill Lines

Acquisition of the resaw and bandmill lines of Counsel Manufacturing Inc., West Coast Sawmill Equipment manufacturers, was announced Oct. 12 by William K. Stamets, Jr., president of Northeast Ohio Machine Builders, Inc., in Columbiana, Ohio.

Stamets pointed out that the acquisition does not include any of CMI's physical plant or real property but does include all manufacturing and sales rights, patents, patterns, parts and design drawings for the sawmill line, which will soon be moved to Northeast's Columbiana, Ohio headquarters.

Five-Day Softwood Lumber Course at Michigan State U. December 7–11, 1959

The course, to cover grading, properties, uses, will be held at the Kellogg Center, East Lansing, Mich. It is designed for wholesalers, retailers, lumber salesmen, inspectors, graders, building contractors, manufacturers and architects.

Cooperating organizations include, the Southern Pine Inspection Bureau; Western Pine Association; West Coast Lumber Inspection Bureau; and California Redwood Association.

Registration fee, $40 per person. Rooms and meals extra. For formal application, write Softwood Lumber Course, Continuing Education Service, Mich. State U., E. Lansing, Mich.

Wood Boat Foundation Bows at Show

Boat builders and dealers attending the annual National Boating Trade Show in Chicago's Navy Pier in September, had a chance to become acquainted with the new Wood Boat Foundation, which was formed earlier this year by a group of wood boat builders and lumbermen.

In an introductory speech at the association's first annual meeting on Septmeber 29th, Mr. Carlton H. Foster, President of Dunphy Boats, emphasized the vital importance of all wood boat builders giving their support to the organization. He pointed out the need for strong factual publicity to educate the boat-buying public to the superior advantages of wood construction in boats. He emphasized particularly that he wanted it clearly understood that the Wood Boat Foundation welcomed progress, new ideas, and new developments. And he concluded that the greatest progress in the boating industry had been made and was still being made through wood construction.

Also at the meeting, a slate of officers was elected as follows: Mr. Foster —President; A. H. Frost, General Sales Manager of United States Plywood—Vice President; and Russell Switzer, President of Switzercraft Boats—Secretary-Treasurer. These officers, assisted by Mr. Alan T. Mann, manager of the Wood Boat Foundation, headquarters at 185 N. Wabash Avenue in Chicago, will guide the association through the coming year.

Onsrud to Hold Production Clinic For Furniture Manufacturers at Stateville, N. C., December 10–12

Onsrud Machine Works, Inc., in cooperation with Garrison Machinery Company, will conduct a furniture production clinic at Statesville, N.C., December 10–12.

The woodworking clinic will offer a detailed presentation of the latest production method made possible through Onsrud machines introduced in the past year. An actual machine of each type will be in operation on the production of parts and operations typical of furniture manufacture.

Plant executives are invited to attend the clinic. For reservations, write: Bob Miller, Onsrud Machine Works, Inc., 7752 Lehigh Avenue, Niles, 48, Ill.; or, Bob Garrison, Garrison Machinery Company, Statesville, N. C.

FAO Survey Shows Phenomenal Growth of Particle Board

A recent survey of the world's forest products industries by the United National Food and Agricultural Organization (FAO) stated that "the particle board industry is the youngest of the existing forest industries but its growth in the past decade has been phenomenal."

The survey reported the following figures for world particle board output (in million square feet, 3/8" basis):

1951 ---	62.1	1955 ---	754.8
1952 ---	124.3	1956 ---	1,244.1
1953 ---	233.9	1958 ---	3,567.4
1954 ---	464.4		

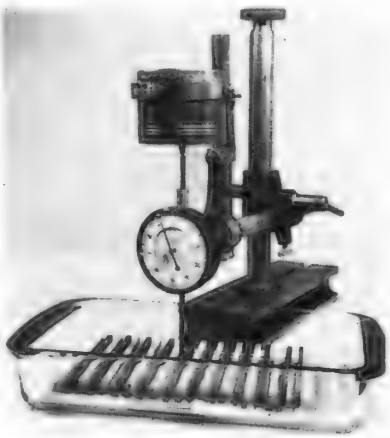


Fig. 1.—Loading device used to measure deflection of test beams resting upon glass racks and exposed to decay organisms in culture dishes. (Cover removed.)

Editorial Correction

Through haste and oversight, a wrong photograph was used to illustrate an article in the August FOREST PRODUCTS JOURNAL. The correct photograph and caption for the article, "Loss in Stiffness Evaluates Decay Resistance of Wood Treated with Copper Naphthenate," appears above.

To add to the crimson hue of our editorial face, the same misalliance was repeated on the cover.

Our apology is extended to authors J. W. Rolff and H. Shen, Vancouver Laboratory, Forest Products Laboratory of Canada.

Insects Take Forest Toll

The tremendous toll that forest insects are taking today and the complexity of control are outlined in a new book being prepared by two Oregon State College forest entomologists —Dr. W. J. Chamberlin and Dr. Julius A. Rudinsky.

Last year in the United States, forest insects killed enough timber to build 600,000 five-room houses, five or six times as much timber as lost to forest fires. The insects killed one-fourth as much pulpwood as consumed in the manufacture of the nation's newsprint. Added losses were caused by insect infestations that did not kill trees out right, but slowed growth and deformed trees.

Lumber Seasoning Courses Nov. 30 & Dec. 7

Two sessions of a six-day course in lumber seasoning will be offered on the West Coast this fall according to a joint announcement by F. E. Dickinson, Director of the California Forest Products Laboratory, and L. D. Espenas, Acting Director of Forest Products Research at the Oregon Forest Research Center. The first will be held in Corvallis, Oregon, beginning November 30, while the other will be held in Richmond, California, beginning December 7.

The two courses will be similar in organization, content and cost. Cooperating with the California laboratory are the Pacific Southwest Forest and Range Experiment Station and the School of Forestry, University of California. The Pacific Northwest Forest and Range Experiment Station and the School of Forestry, Oregon State College, are cooperating with the Oregon laboratory. The U.S. Forest Products Laboratory, Madison, Wisconsin, is cooperating with both organizations in providing course materials.

The course content is aimed primarily for the benefit of kiln operators, but personnel from management, supervisory and sales staffs should find attendance profitable as well as interesting; and they are encouraged to attend. The instruction will consist of lectures, demonstrations, laboratory exercises, and actual operation of the drying equipment at the host laboratory.

Enrollments will be limited to 30 persons. Fee of $75 a person defrays actual costs. Application forms may be obtained by writing to Department of Conferences and Special Activities, University Extension, 2441 Bancroft Way, Berkeley 4, California, or to the Oregon Forest Research Center, P. O. Box 571, Corvallis, Oregon.

Kiln-Drying Course at University of Illinois, March 21–25, 1960

K. R. Peterson, wood technologist at the University of Illinois, announced that the Department of Forestry, University of Illinois College of Agriculture, will act as host for the 1960 Kiln-Drying Short Course, which will be conducted cooperatively with the following agencies: Delmhorst Instrument Company, Foxboro Company, Iowa State University, Lumber Drying Specialty Company, Michigan State University, Moore Dry Kiln Company, Purdue University, Standard Dry Kiln Company, Southern Illinois University, University of Michigan and the Wel-Dri Company.

Anyone engaged in drying lumber or in handling and manufacturing wood products can benefit from this five-day course of instruction, demonstration and discussion. Management personnel, kiln operators, lumber dealers, architects and others associated with the production and sale of forest products will find in this course solutions to many problems commonly encountered in the drying of wood. Participants are especially urged to bring specific problems for consideration during special discussion periods.

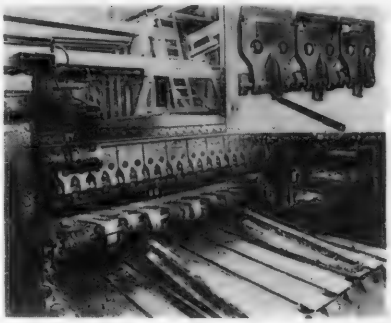
For further information about the short course, write to: Kiln-Drying Short Course, Department of Forestry, 219 Mumford Hall, Urbana, Illinois

Heavy-Duty Brush Chipper

Mitts & Merrill, Saginaw, Michigan, manufacturers of the famous M & M Beaver line of Brush Chippers, announces a new heavy-duty Brush Chipper which is the largest, most powerful chipper on wheels being made today. The new heavyduty M & M Beaver will handle, with ease, any size length of branches or tree trunks up to 8 inches in diameter.

The new chipper features a built-in blower which regulates the direction and distance of chips. A large, heavy rotating cylinder in between heavy-duty bearings, eliminates the need for an overhanging flywheel and is a special feature for safety and productivity in this type of machine. All welded construction and special alloy steel plus simple design with the least amount of parts assures practically trouble-free operation and low maintenance costs.

NEW PRODUCTS and Literature



New Veneer Knife Clamp

A new veneer knife clamp, has been developed for positive knife holding and improved veneer quality, while providing rapid knife changing, reduced maintenance, and the use of thinner, less costly knives. Especially designed to absorb the shocks of heavy production runs, the clamps enable knives to cut faster and last longer.

No special equipment or tools are required for installation or maintenance. For further information write Elford Plywood Machinery, Inc., 2929 N.E. Alberta Avenue, Portland, Oregon.

Automatic Edge Marker

Edge marking of lumber with company or brand name and species can now be accomplished automatically through the use of the Conveyor Line Marking equipment. The printing equipment is easily installed on the "green chain" of any lumber mill at a point following the trimmer or button saws. The lumber moving down the "green chain" contacts and rotates the printing roller which makes the desired impression. No additional labor is necessary. Speed of operation is determined by the speed of the lumber moving along the "green chain". For additional information, contact the Automatic Marking Equipment Co., Inc., 207 Fulton St., New York 7, N. Y.

New Staple Gun Drives Long Staples At Low Air Pressure

A new Duo-Fast, air-operated staple gun that will drive long, heavy staples into hard materials at low air pressures has been introduced. The new tool, Model S–762, operates at air pressures as low as 50 pounds, and it will drive staples up to 1½ inches long rapidly and securely, with no recoil. The gun features rapid front-end loading, and is equipped with a safety-trip operating mechanism. Made of magnesium, it weighs less than 5½ pounds. For complete details on the Duo–Fast S–762 staple gun, write Fastener Corporation, 3702 River Road, Franklin Park, Illinois.

Ekstrom, Carlson & Co. Has New Improved Wide-Arm Rip Saw

Improved version of the Ekstrom, Carlson Model E Ripsaw has a 48-inch ripping capacity to the right and to the left of the saw blade, with the rip fence in place. For greater rigidity and safety, the saw employs the undercutting principle. Variable speeds provide the correct feed rate for the material and the ability of the operator. An adjustable and removal throat insert of soft metal eliminates sliver jams and prevents damage to the blade.

For additional information, write Ekstrom, Carlson Co., 1400 Railroad Ave., Rockford, Illinois.

Sealer On Hardwood Panels Dried in 36 Seconds At Cascades Plywood Corp.

Installation of a driQuik infrared oven at Cascades Plywood Corp., Lebanon, Oregon, has resulted in faster and more efficient drying of sealer on prefinished hardwood panels, according to J. R. Stillinger, Technical Director of the Corporation.

Secret of the fast-drying oven, designed by the Dry Clime Lamp Corp., Greensburg, Indiana, is applying the right amount of heat at the right time, said Stillinger. The 42-foot oven has three temperature zones, each with its own time-temperature controls.

The new oven takes up much less space than a convective oven, there is practically no maintenance, and it has reduced down time on the line.

New Tree Crusher

Just introduced is a "small" 95,000-pound electric Tree Crusher which has been designed specifically for removing unproductive forests such as are found in broad expanses of the southeastern United States and other areas. The $75,000 machine is being introduced this month by R. G. LeTourneau, Inc. of Longview, Texas. The company previously produced Tree Crusher models three times larger which now are working successfully in Venezuela, Peru and Liberia. Photo above shows experimental prototype of the new G-40 Tree Crusher during job tests against scrub forests in North Carolina. The tests indicated the machine will smash three to four acres an hour, at a cost of $3.50 per acre.

Timesavers Announces Improved "Shapesander"

A new improved model of the versatile Timesaver Shapesander is now available. This wide-belt sander features the famous Timesaver "floating sanding head" which sands on the topside of the work. It provides close control of stock removal while its "floating action" allows for slight variations in stock thicknesses without difficulty. Due to the small radii of the feed and contact rolls, small radius curved and serpentine wood parts can be machine sanded with ease. It can also be used for straight wood stock without modification. Available in an 18 inch-belt width, this low-cost Timesaver Sander handle such wood parts as chair back, drawer fronts, rocker runners, curved slats, water skis, chair seats, etc. For additional information and prices write Timesaver Sanders, Box 7446, Robbinsdale Station, Minneapolis 22, Minn.

What's New in *Technical Publications*

USFPL Publications

A new handbook, **Nailing Better Wood Boxes and Crates** by L. O. Anderson, illustrates the principles of fabrication with nails for two box and two crate styles. The 40-page booklet, AH No. 160, may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. for 20 cents.

Other publications recently released by the FPL include:

Outdoor Exposures of Container-Grade Paper-Overlaid Veneers, by A. A. Mohaupt, presents results of toughness tests and visual examinations of 16 container-grade, paper-overlaid veneers that were exposed outdoors for a year. Report No. 2151.

A Method for Rapid Measurement of the Rate of Decay of Free Vibrations, by W. L. James, explains techniques for determining the internal friction in wood by measurement of the rate of decay of free virbations. Report No. 2154.

Torsion of Rectangular Sandwich Plate, Report No. 1871, and **Simply Supported Sandwich Beam—A Nonlinear Theory,** Report No. 2157, present engineering data on stresses in sandwich construction.

Groundwood and Chip Groundwood Pulping and Papermaking Experiments, E. R. Schafer and Axel Hyttinen, gives data on experiments with ponderosa pine. Report No. 1947.

New Wood-Use Series

The Institute of Forest Products, University of Washington, Seattle, has available a 14-page illustrated circular entitled Composts and Mulches from Wood Waste. By Stanley P. Gessel, the circular explains the relationships between soils, composts, and mulches.

Timber in North Carolina is the title of an attractively illustrated report by the Forest Service. The report gives data on forest acreage, timber cut, future requirements, trends, and forecasts. It is listed as Forest Resource Report No. 15, U. S. Department of Agriculture, Forest Service.

Reichhold Chemicals, Inc., have released a new technical bulletin on Chlorophen 663 and 664. The bulletin contains specifications and possible applications for Chlorophen in both powdered form and as pellets.

Unit Load Container

The National Wooden Box Association has available an informative phamplet, entitled "Bin Boxes," covering wooden unit load containers. This 12-page illustrated booklet contains information gathered by the NWBA from box manufacturers, industrial and agricultural firms, and carriers.

The pamphlet discusses the economics of unit handling, its origin and increasing importance. Guidelines for effective construction o bin boxes are established, and fou general types are described.

For a complimentary copy, con tact the National Wooden Box As sociation, 402 Barr Building, Wash ington 6, D. C.

New NWPP Booklet Now Available

"Here's How You and the NWPI Make a Powerful Sales Team fo Wood Products," is a new booklc that covers in question and answe style the reasons why the Nationa Wood Promotion Program wa started, what it was designed to dc and what it is doing in advertising merchandising, technical promotio and in intra-industry activities.

Single copies are available fron Wood Information Center, National Lumber Manufacturers Association. 1319 18th Street, N. W., Washington 6, D. C.

FPL of Canada Publications

The following new publications are available on request from either the Ottawa or Vancouver Laboratory, Forest Products Laboratories of Canada. List of Publications of the Forest Products Laboratories of Canada (Rev. July 1959); Improved Profiles for Veneer Knives, A. O. Feihl; Toxicity Tests of a New Tropolone, B-Thujaplicinol (7-Hydroxy-4-Isopropyltropolone) Occurring in Western Red Cedar, J. W. Roff and E. I. Whittaker.

NAMES in the NEWS

Dr. Jerome F. Saeman, U. S. Fore Products Laboratory, was recently ap pointed chief of the Laboratory's div sion of wood chemistry. Saeman, a spe cailist in research on lignin hydrogen tion, cellulose hydrolysis, and the pr duction and utilization of wood sugar will be in charge of the Laboratory's e tensive work on conversion of wood t useful chemicals, investigations on nitr cellulose, and on fundamental studies the nature of wood and its chemical con ponents. He is a frequent contributor t the Journal.

Carl de Zeeuw, New York State University, College of Forestry, is on leave of absence to permit him to take an 18 month tour of duty at the University of the Phillipines College of Forestry as visiting professor of forest utilization.

Dr. Reavis C. Sproull, Richmond, Va., is been named director of research and development of the Chesapeake Corporation of Virginia. Dr. Sproull will establish a program at Chesapeake to develop new processess and new and improved products at the kraft pulp and paper mills to assure more complete utilization of the wood resources of Chesapeake's operating area.

Production Development Company, Inc., Raleigh, N. C., has added **Anco Luning-Prak** to its staff. Mr. Luning-Prak formerly of the Netherlands, is a methods and equipment development engineer and an expert on polyester finish application.

Two personnel changes have been made by the Southeastern Forest Experiment Station, Asheville, N.C. **Rufus Page,** formerly in charge of forest utilization services for the state of Georgia, was appointed assistant to W. R. Smith, chief, forest utilization research. **Paul J. Bois,** technologist at Asheville for three years, will replace Page in Macon, Georgia.

Harold Sprunger, vice president and director of Dunbar Furniture Corp., was elected 1959–60 president of the National Association of Furniture Manufacturers Assoc. Sprunger, 33, is the youngest executive ever chosen to head the NAFM.

R. J. Lodge, general manager, Borden Chemical Company, recently announced appointment of **A. H. Haigh** as technical representative of Borden Chemical's resins and chemicals department. Haigh, who will specialize initially in particle board production, was formerly with American Parboard Co.

M. A. Bell, former representative of Carthage Machine Co., has formed his own business as sales representative of manufacturers of chipper knives, debarking equipment, screens, etc. New headquarters of "bell-machinery" is 914 North 19th St., Birmingham, Ala.

Protection Products Manufacturing Co., Kalamazoo, Mich., producers of chemical preservatives and water repellents, recently appointed **L. I. Winebrenner** Technical Director. Winebrenner will direct all research, product development, quality control and technical service activities.

Koppers Wood Preserving Division on the East Coast has been reorganized, according to an announcement by **Douglas Grymes, Jr.,** vice president and general manager of the Division. The reorganization resulted in the following appointments: **R. H. Devine** is now assistant to the general manager, with headquarters in Pittsburgh; **T. J. McGinnis** was appointed manager of the Northeastern District with headquarters at Newport, Delaware; **W. M. Barnes,** manager Southeastern District, Charleston, S. C.; and **W. F. Klug, Jr.** was appointed manager of the Pittsburg District.

L. J. Marwardt retired September 30 as assistant director of the U. S. Forest Products Laboratory at Madison. Mr. Markwardt, a charter member of FPRS, has been an international "ambassador of research goodwill" not only for the Laboratory but for the entire forest products industry. He will continue to reside at Madison while he serves as technical consultant for several industrial concerns in forest products fields.

"FPRS Salutes"

Men Contributing Time and Effort for Furtherance of the Society and Wood Industry

Harry L. Russell—Arkansas FPRS Membership Chairman. A few months back the Arkansas Gazette carried an article with a lead line that read—"Harry L. Russell is a man with hot ideas".

This is a most appropriate tag-line for Harry, a man whose ideas have been hot enough to result in the design and construction of more than 2,000 dry kilns, since he formed the Russell Dry Kiln Co. in 1939. A man born and raised in the lumber industry, Harry was a kiln foreman at 18. Today, kilns of his own design and manufacture are in use at 900 plants that turn out products that range from fish plugs to furniture.

FPRS Membership Drive

That tag-line is equally appropriate for Harry's efforts in our recent membership drive. His ideas made him our hottest producer in the past year.

How did he do it?—with a veritable barrage of letters, phone calls, and personal visits, all calculated to promote one theme—the advantages of being a member of FPRS. In fact, he devotes at least one full day a week to Society work. He also sees to it that road men employed by Russell Dry Kiln Co. carry membership applications and literature.

New Members

What were the results? Here's a partial list of new members Harry has brought into the FPRS family: Arkansas–Louisana Gas Company; Winrock Farms—Winford Rockefeller; J. Brown, Brown Mfg. Co., Pine Bluffs; L. Burroughs, Lewisville Flooring Co.; Lewisville; A. Fuller, Fuller Lbr. Co., Lewisville; S. Harris, Warren Oak Flooring Co., Warren; P. Kay, West Memphis J. J. Schmelzer, Arkansas Foundry Co., Little Rock; and, H. E. Woodson, Russell Dry Kiln Company.

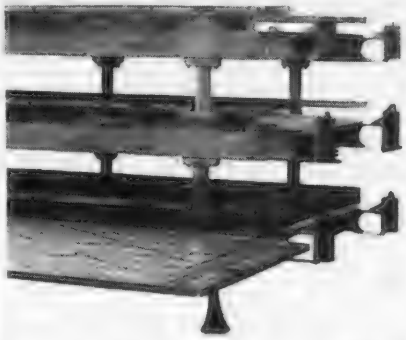
That same article we quoted earlier said Harry Russell has two pet opinions he stresses: One, consumers can get better quality lumber if they demand it; two, improper seasoning destroys more lumber than forest fires.

We salute Harry for adding a third verse to his sermon—"It's a good idea to belong to the Forest Products Research Society."

Anybody else got any hot ideas?

METAL AUTOCLAVE

Washington provided hot-oil heated steel platens and three-high support assembly for this metal autoclave which bonds aluminum and magnesium together with plastic under heat and pressure, eliminating rivets, welds in aircraft construction.



Other "Washington-built" products

Featured above is one of many specialized items produced to specifications for shipyards, plywood, board and pulp mills, construction and logging firms, manufacturers of machinery and aircraft, atomic energy projects and other world-wide industries.

If you have a problem relating to the engineering or production of any item of large scale equipment, machine or component part, *one-of-a-kind or in quantity,* we have the diversified facilities and experience of more than seventy-five years to produce it for you at least possible cost.

The self-contained Washington facility provides engineering, iron and steel casting, heat treating, machining and fabricating. *Let us quote on your specifications. Write Washington Iron Works, 1500 Sixth Ave. South, Seattle 4, Wash.*

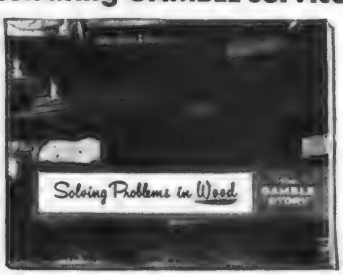
WASHINGTON IRON WORKS
WASHINGTON IRON WORKS
Since 1882
Standard Equipment...
LOGGING EQUIPMENT—TRAKLOADERS, YARDERS, LOADERS AND BLOCKS
CRANES, CABLEWAY SYSTEMS AND ALL TYPES OF DERRICK AND HOISTING UNITS
HYDRAULIC PULP BALING PRESSES, MULTIPLATEN HOT PRESSES AND ACCESSORY EQUIPMENT
SPECIAL MACHINERY AND PARTS, FABRICATIONS, FORGINGS, WELDMENTS, CASTINGS, HEAT TREATING AND MACHINING

How can CREATIVE WOOD ENGINEERING help you?

- Research in improving present wood products?
- Development of new wood products?
- Research in completely new "wood-combination" materials?

If your problem involves wood (and maybe it should) Gamble can help! Gamble Brothers' 65 years of creative wood engineering has greatly expanded the usefulness of America's great renewable resource. Gamble has pioneered new processes and new products involving wood-and-fiberglass, wood-and-plastic, wood-and-metal, wood-and-synthetics and countless others. Perhaps our technical knowledge of the properties of more than 130 commercial wood species, and the creative application of this knowledge to today's design and development problems could be of service to you.

Send for FREE booklet Illustrating GAMBLE services



This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Bros., Inc., 4633 Almond Ave., Louisville 9, Ky.

GAMBLE BROTHERS
Incorporated
Louisville 9, Kentucky

EMPLOYMENT *Opportunities*

Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Employment Wanted

574—Chemistry-engineering combination. 6 years experience in chemistry; 5 in engineering with industry. Holds degrees in chemistry and biology, plus graduate credits. Now located midwest. (Oct.)

576—Production Mgmt. or product development in plywood, particle board, etc. Also sales promotion. Two years experience in plywood production, Calif. BS. in Forest Products, U. of Washington. Prefers Coast but will consider elsewhere. (Oct.)

577—Avail. Jan. 1. Finishing M.S. in forest products chemistry. Some experience in pulp and paper research. Courses or experience in ultra-violet and infra-red spectrophotometry, microscopy, ion-exchange, chromatography. Desires position in chemistry, preferably bark or lignin research and development. Age 27. Married. Locate anywhere. (Oct.)

Positions Offered

E 360—Association field representative. Wide range of work; some travel. Recent graduates in wood technology or forestry. Some experience. Job will provide experience in sales and technical consultation. South. (Oct.)

E 362—Michigan Case Goods plant seeks assistant to superintendent having considerable machine room production background and experience—permanent position with substantial opportunities for advancement. (Oct.)

E 363—Sales reps. for hardboard manufacturer in Eastern half of U.S. Major firm; full benefits; experience desirable. (Oct.)

E–368—Laboratory assistant and plants inspector wanted. Must have BS in wood technology. No experience required. Should be 25 or younger. (Nov.)

E–370—Trade association expanding field promotion department. Will add 19 men at locations throughout U. S. Must have qualifications and understanding equivalent to that of graduate or new graduate in architecture, civil engineering, industrial design agricultural engineering, or forest products. Requires ability for self expression and capacity for aggressive promotion. (Nov.)

E–369—Developing engineer for expanding technical group on West Coast. Company manufactures lumber, veneer, allied products. Will be responsible for design of pilot plants for new products and engineering in existing plants, some product development. Must be able to work with production personnel. Engineering degree, experience in forest products, ability to work with little supervision required. Salary attractive. (Nov.)

E 371—Have several openings in our organization at this time for experienced supervisory personnel capable of supervising mill, machine, and cabinet departments. We manufacture a large and varied line of case goods and chairs for household and institutional uses. (Nov.)

E 372—Have several openings at this time in our organization for qualified personnel in the sales field. Our principal products are for use in retail establishment consisting basically of store fixtures for merchandising purposes. (Nov.)

(Professional Card)

MATER ENGINEERING

Professional consulting engineers for the forest products industry.
Sawmill automation, design, modernization, integrated plants, complete technical and economic studies.

P. O. Box 410
CORVALLIS, OREGON
Phone Plaza 3-7335

New Independent Research Lab To Serve Pulp & Paper Industries

A new research laboratory termed "the most complete independent forest products laboratory west of the Mississippi" has begun operation at Seattle Washington.

Technical director of the new enterprise, known as Fiber Research, is E. G. Putnam.

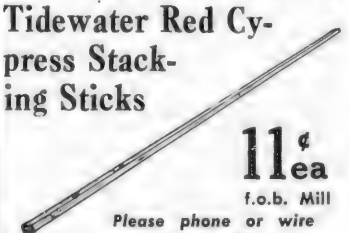
Function of Fiber Research will be to collaborate with scientific personnel throughout the pulp, paper, and board industries, said Putnam.

The new laboratory will have both batch and continuous pulping facilities for the production of chemical semi-chemical, and mechanical pulp, as well as TAPPI test equipment.

Fiber Research represents the combined efforts of the Pulp and Paper Division of Hill and Ingman and the Washington Iron Works, it is located at 3104 Western Avenue, Seattle, Wash.

(Advertisement)

One Car 8-foot SIS 15/16 Tidewater Red Cypress Stacking Sticks



11¢ ea
f.o.b. Mill

Please phone or wire your order

GAIENNIE Wholesale Lumber Co.
BOX 1774, SHREVEPORT, LA.

General Gavin Speaks Out for Basic Research—

"Let's Move Forward with New Ideas"

Lt. General James N. Gavin, Ret.,
Executive Vice President,
Arthur D. Little, Inc.,
Cambridge, Mass.

Graduate, U. S. Military Academy, West Point. Best known for his work as Chief, Plans and Operations, Plans and Research, and Research and Development for the Department of the Army.

SINCE TIME IMMEMORIAL trees have satisfied almost all of man's needs for food, shelter, weapons—the essentials for survival. From trees came the wheel, fire, ships, and paper—man's first great steps in civilization.

But today's technical revolution is slowly eroding the ground from under this pivotal position that trees have so long held. No more do we see wooden spokes and steering wheels, except as a luxurious touch. Metals and plastics are replacing wood in the soldier's hand weapons, and aluminum houses and fiberglass boats are becoming more popular. Research has brought this about, and research is the only way the forest products industry can win this competition with other materials of transient glamour and appeal.

So, too, on the international scene, research is our first and most important weapon in the battle for liberty, for the battle is being fought by strategy in the world marketplace.

In the last decade, it became apparent that this is a close tie between economic strength and research. Now it is an established fact that continuing scientific discovery is intermeshed with increased industrial production and economic growth in our country. Upon economic growth we must calculate our survival. The last decades have also shown us that the integrated economic strength of the free world is a necessity. The integrated economic strength of the western world is crucial, not only to support defense machinery, but because the Sino–Soviet bloc and the Free World are currently engaged in the hottest economic war the earth has ever seen.

How Will We Meet Competition?

Traditionally, the United States has been proud of her ability to meet competition. We have thrived on our competitive system. But we cannot rest on our gains. Our industry has need of its highest intelligence, for we are entering an era of even more rugged competition than before. We need faster economic growth.

Research is the key to economic growth of our industry and our country. After World War II, our massive wartime research created a large electronics industry, it brought automation to many processes, and developed aircraft, petrochemical, and pharmaceutical industries. Forest products also felt the effects of concentrated research. During World War II, we learned to adapt wood and paper to a multitude of new uses, and while creating substitutes for materials then in short supply, we made new products and new markets. Corrugated containers replaced wooden boxes, fiber drums replaced drums, and paper-base laminates and wall-board emerged. Plywood was used in bombers during the war. Weather-proof adhesives allow us to use wood in new ways, as in the wooden-hulled mine sweeper of our Navy today. The word "paper" has changed in meaning. It used to denote only cellulose fibers, but now it may contain glass, quartz, synthetics, or metals. In effect, research upgraded the basic raw material.

War-born research expanded the number and variety of forest products, but it also bred competitors in metals, plastics, and chemicals. Competition also arose within the industry, itself, and it is increasing both here and aboard. Canada's white pine exports to Britian dropped 60 percent as Russia stepped in, and the Ontario Forest Industries openly admit: "That kind of competition we don't know how to meet." But that kind of competition will increase.

Challenge of Tomorrow

The day has passed when Americans can return from all foreign countries, and complacently report that the machinery is anti-diluvian and the labor underpaid. We've felt the competition from quality plywood made in Japan on fine automatic equipment that results in low consumer cost. It is we who should think about replacing old equipment with new. Our competitors have taken ideas from us and improved upon them, but they have not stopped there —nor can we. This is the challenge of tomorrow's world, and the answer lies in extensive research. How we meet the challenge depends upon the imagination we put into research. In the short range, this will mean applied problems and engineering, and at this level nobody else will do the kind of research that will benefit forest products. Fabricators will continue to use the cheapest materials that suit their purposes.

Already applied research has created a trend. Forest products can no longer compete as simply a natural resource industry. Increasingly refined products are impressive, and they indicate the potential versatility of wood. There is the trend toward new processing methods, log harvesting, chemical debarking, wood preservation, toward the use of automatic controls, high-yield pulp processing, and the increased use of chemical by-products and wood waste. All this comes from research. Every month one reads about a new wood product that is superbly fitted to its use, economical, and in many instances, elegant.

An address presented at the Official Luncheon of the 13th National Meeting of the Forest Products Research Society in San Francisco, Calif.

Our Research Lacks Direction

All these remarkable products and processes come from research, that seems to be directed toward improving the product, developing standards, controlling quality, and introducing new products. Is it sufficient? Or could individual companies become more analytical in evaluating the possibilities of research for their own profit, and in using knowledge already available? Another question: Is there a direction to the research of the industry as a whole? It is not apparent that there is, to an outside view, although it is apparent that an industry-wide research direction can be phenomenally profitable. Look at the associations of the aluminum people, the glass, petroleum, and petrochemical organizations. These research associations are at the heart of our robust competition. They are striving to be at the forefront. Many of these industries are now and will continue to devote research effort toward overcoming an obstacle that does not face the wood industry—namely, the future diminution of their present natural resources. The tree is a replenishable source, and wood products have already substituted for wartime materials in short supply. It is abundantly clear that a venturesome wood technology can give us economical and attractive products to replace those metal and other products that come from a limited resource.

The forest products industry is on the threshold of discovery, and it is analogous to the petroleum industry several decades ago in that the full use of the raw material has not been achieved. Prior to modern refining methods for instance, the use of a crude oil from a given source was determined largely by its native composition. Today, catalytic conversion and the use of additives in modern cracking make a wide variety of crude oils into better than the best of earlier lubes. Furthermore, the exploitation of oil has led to a large pentochemicals industry. The utilization of the tree has not begun to reach this level.

Basically, wood is used for sawtimber, veneer, and fibrous raw material for such products as paper and regenerated cellulose. Although waste is recovered more and more for particle board and chemicals, we still use only about 40 percent of the tree substance in a mixed stand of trees. Although wood is a replenishable resource for organic chemicals, we have, understandably, concentrated on isolating chemicals from pulping residues.

Let's Use the Whole Tree

Pulping residues are often less amenable to treatment than the native wood. What are we doing about the chemical use of the whole tree? There is evidence that this is going to happen. The literature reports of new methods being explored for the separation of bark and wood components—and one of the boldest of these methods, incidentally, is Russian. Their dissolving of wood in tetralin could lead to physical or chemical fractination.

Countries rich in forested land but poor in coal and oil are beginning to see the advantages of chemically utilizing their trees. Here, and in Japan, Russia, Sweden and other countries the problem is attracting attention. Silvichemical industry has some advantages at the outset. In the petrochemical industry, considerable trouble must be taken to add oxygen to the raw materials to form alcohol and other products. In many instances, a silvichemical industry, with its raw material rich in carbohydrates, has a much more attractive energy base for approaching the synthesis of related derivatives. In this direction, we see some work on the solvent extraction of lignin, a modest attack on hydrogenation, and some work on pre-treatment, the use of ultrasonics, and irradiation. But, silvichemicals are a wide open field. Will the United States take the initiative, or will we wait for foreign competition to motivate our work? Here is a field in which the rewards for imagination will be bountiful—the two-thirds of the forest that we now throw away.

Tomorrow's Possibilities

Let's take a hard look into the crystal ball of tomorrow's possibilities. Let us suppose that we were starting out from scratch in an undeveloped country, such as China, with forested land and all of modern technology and knowledge accessible—but no commitments to equipment, procedures, roads, markets, or traditional expectations. What might be done? We could, at last, deal with the tree itself as an industrial raw material to be controlled for economic ends.

The latest and best automatic equipment for process quality control, and precise testing instruments would be one avenue of pursuit. Direct aerial seeding and repellents to predators would be helpful in using trees as a crop. Forest genetics would play an important part. Grafting techniques are, for example, giving us hope of producing a giant Douglas-fir with desirable fiber characteristics. In forest pathology we are already using antibiotics and radioactive isotopes. Tracer elements are being used in growth studies, and soil research is giving us hope that we can grow trees faster.

As an exercise in detachment, it may be fruitful to ask what could be done if one had free rein to use our present technology most efficiently. Even so, when one asks about the growth of trees, the effects and control of weather, and the chemical constitution of wood there is always a vast area of unknowns. The fact is that today we do not know enough to take full advantage of the tree as a natural resource.

We have much to learn about trees. George Bernard Shaw once said that: "Except during the nine months before he draws his first breath, man never manages his affairs so well as a tree does." With deeper knowledge, isn't it possible that forest agriculturists will grow trees more rapidly, inuring them against disease as they grow, and producing mature trees with desired chemical and fiber structure characteristics? Defects now overcome in the factory might be tackled in the forest. Unimagined developments in forest products will issue from research in biology, genetics, chemistry, and physics.

Now it is to the advantage of the wood industry to speed this process of discovery by supporting basic research in universities or foundations. A direct impact can be achieved by joining together and making an industrial investment in long-range problems. Co-operative support is clearly necessary, since basic work is laborious, venturesome, and costly.

Basic Research Is Not Competitive

Basic research forms the cornerstone on which all application, and therefore profit, rests. Companies, industries, and countries may compete for the ingenious applications and patents, but basic research is *not* competitive. To enhance basic research we must liberate ideas and exchange them with the rest of the world. It is a curious truth that we will heighten our own economic powers by applying the knowledge that we and our competitors have gained together.

Only by extensive research in individual industries will the basic discoveries be exploited, but the promotion of work in genetics, physics, astronomy, meteorolgy, and other fields here and around the globe should not seem remote, for the acceleration of this fundamental work will speed the breakthroughs on which our future will be determined. Goethe has said: "Daring ideas are like chess men moved forward—they may be beaten, but they may start a winning game." Let us move forward now with new ideas.

Fig. 1.—Full-scale trestle replica test ready for ignition. Douglas-fir timbers were treated to refusal with 0.9 percent phosphorus as triaryl phosphate in a creosote-petroleum mixture.

Fig. 2.—Same trestle replica at peak fire, 45 seconds after ignition. Temperature reached 900° C or higher.

Fire Retardants for Wood

TREATED WITH OIL-TYPE PRESERVATIVES[1]

R. M. Gooch, D. L. Kenaga, and H. M. Tobey[2]
The Dow Chemical Co., Midland, Mich.

For some years, the potential fire hazard present in trestles made of timbers treated with oil-type preservatives has been a source of concern among western railroads. This paper describes research aimed at elimination of this hazard and reviews some of the problems associated with the selection of fire-retardant preservative systems suitable for conditions of exterior service.

Mechanism of Retardancy

A complete discussion of the mechanisms of combustion and its inhibition is outside the scope of this paper. A brief general review of those factors thought to be involved in the system under study, however, will serve as useful background. It should be remembered that theoretical investigations of combustion reactions are usually carried out on model systems such as heptane vapors or pure cellulose.

The Authors: R. M. Gooch holds a BS in chemical engineering from the University of Michigan, and is a research engineer of the Biochemical Research Department.
Duane Kenaga holds a BS in chemical engineering and a BS and MS in wood technology from the Univ. of Michigan. He also is a research engineer in the Biochemical Research Department.
Henry Tobey holds BS and MS degrees in chemistry from the University of Oregon.

A phosphorus–halogen mixture added in proper ratio was effective in reducing the fire hazard of trestles treated with oil-type preservatives.

Treated wood, which contains a combination of ligno-cellulosic material with hydrocarbons of varying degrees of saturation presents a much more complex problem.

Combustion of Carbohydrates: The combustion of carbohydrates (2,3,10,11,12,13)[3] such as cellulose is generally regarded as proceeding in two steps. The first of these, the "flaming" reaction, involves pyrolytic degradation through which carbon, tars, flammable hydrocarbons, and water are formed. The second or so-called "glowing" portion of the reaction results from oxidation of the carbon through carbon monoxide to carbon dioxide:

1) $C + \frac{1}{2} O_2 \longrightarrow CO$
2) $CO + H_2O \longrightarrow CO_2 + H_2$
3) $H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$

The water-gas reaction, in which carbon monoxide is further oxidized, generates hydrogen with the result that large quantities of heat are subsequently liberated as water is formed.

[1] Presented at Session VI, Wood Preservation, FPRS 13th National Meeting, June 28-July 3, 1959, in San Francisco.
[2] Mr. Tobey is now with the Chapman Chemical Co., Memphis, Tenn.
[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

Those compounds which catalytically inhibit the flaming of cellulosic materials are thought to function through Lewis-acid induced dehydration of the carbohydrate chain. Their apparent effect is to facilitate conversion of the carbohydrate directly to carbon and water at the expense of combustible intermediates. Certain phosphates and halides that are acidic or form acid-like decomposition products at flame temperatures will act in this manner.

Schuyten and coworkers (12, 13) have listed the requirements of a flameproofing agent for cellulose as follows:

1) Must be present or produced from its precursor at a temperature close to that of burning cellulose.
2) Must not be volatile at 300° to 500°C.
3) Must not burn readily by itself.
4) Must be a Lewis acid (electron acceptor) or capable of forming a Lewis acid at the temperature of burning cellulose.

The control of the "glowing" reaction of cellulosics depends upon the decrease in conversion of char to carbon dioxide. Those compounds, which hold water tenaciously at elevated temperature, apparently interfere with reaction 2) shown above to the extent that "glowing" occurs with difficulty, if at all. The phosphoric anhydrides are particularly effective, although oxides of boron perform well also.

Combustion of Hydrocarbons: The flaming of hydrocarbons generally in-

Fig. 3.—Same replica trestle as in Figs. 1 and 2, six minutes after ignition.

Fig. 4.—Same replica trestle eight minutes after ignition. Some local burning still persists in protected pockets. Char is about ¼ inch deep.

volves volatilization followed by degradation and gas-phase oxidation (1,6,7). Flames are propagated through the complex action of numerous reactive species, many of which are present as free radicals capable of initiating branching chain reactions. The simplest of combustion reactions, notably the combination of hydrogen with oxygen, proceeds explosively largely due to the chain branching reaction:

4) $H\cdot + O_2 \longrightarrow OH\cdot + O.$

The introduction of very small quantities of iodine reduces the rate of this reaction several fold, presumably through a mechanism such as:

5) $I_2 + H\cdot \longrightarrow HI + I\cdot$

Bromine performs in much the same manner. Chlorine, however, is less efficient because of the tendency of the chlorine free radical to recombine with gaseous hydrogen, and thereby generate hydrogen chloride and another hydrogen free radical.

More complex systems are not well defined, although reactions such as:

6) $CH_3\cdot + RX \longrightarrow RCH_3 + X\cdot$

(where X is a halogen) are possible. For the purposes of this study, the precise mechanism is not so important as the fact that the halogens do act in the vapor phase to supress flaming.

Early Work

Early work (8) published in 1952 by the University of Idaho Forest Wildlife and Range Experiment Station describes the use of triphenyl phosphate in pentachlorophenol-petroleum solutions used for the preservation of fence posts. These results stimulated personnel from the Atchison, Topeka, and Santa Fe Railway System to conduct fire tests on a full-scale trestle replica made with stock that had been treated with creosote-petroleum preservative containing 1.9 percent phosphorus as triphenyl phosphate.

Concurrently, a basic research project on the fire problem in treated wood had been underway within the Biochemical Research Laboratory of The Dow Chemical Company. As a result, a joint research program evolved in which Dow performed laboratory experiments while the Santa Fe Railway retained the responsibility for field evaluations.

1) The effect of the triaryl phosphate addition to creosote-petroleum was demonstrated. Although triphenyl phosphate was used by Santa Fe, later tests involved other triaryl phosphates.

Fig. 1 through 4 illustrate the typical full-scale test. In the first picture, the tumbleweeds are placed ready for ignition. The Douglas-fir timbers were treated to refusal with 0.91 percent phosphorus as triaryl phosphate in a creosote-petroleum mixture. Fig. 2 shows the peak fire, which occurs within about 45 seconds from the start of the test. Temperatures at this time average approximately 900°C. at a point immediately under the trestle deck. Fig. 3 shows the fire after 6 minutes. In Fig. 4, taken 8 minutes from the start of the test, the characteristically sharp decrease in flaming had occurred, although burning persists in protected locations.

Fig. 5, which again illustrates the effect of triaryl phosphate, compares time-temperature curves obtained from test fires on trestles of like design. Creosoted stock for the two structures was retreated under similar schedules with solutions of differing phosphate concentration. Analyses of representative borings from those members in each structure that exhibited similar solution retentions indicated an average phosphorus pickup of 0.10 pound per cubic foot in the outer quarter-inch of wood treated with the solution of lower concentration. The comparable figure for the solution of higher concentration was 0.14 pound per cubic foot in the outer one-quarter inch.

2) The influence of carrier volatility on fire hazard was determined. Since burning of full-scale bridge replicas is costly and cumbersome, a smaller field-test method was devised. For the new test, a two-third scale demountable replica was built. The entire structure was covered with asbestos except for a removable panel about 3 feet wide by 14 feet long located in the center of the deck. This panel, the underneath surface of which approximated that of the Santa Fe's ballasted deck trestle, served as the test specimen.

The panels were constructed of 2 inch stock that had been pressure treated with the fire-retardant solution under study. Burning times, as well as panel weights before and after burning, were recorded. As in the full-scale test, an accumulation of dry tumble weeds served as a flame source.

Table 1 compares the performance of a medium residue creosote—high-boiling petroleum mixture with that of a much lower boiling petroleum oil that contained 5 percent of pentachlorophenol. (See Tables 2 and 3 for analyses of oil carrier used). Note that approximately two years of weathering does not effect significantly the flammability of creosote-petroleum treated panels. In the pentachlorophenol-treated panels, the hazard ranges from extremely high, immediately after treatment, to relatively low after less than a year of weathering. The influence of the triaryl phosphate additions is apparent in both systems.

3) The effectiveness of other compounds was studied. Laboratory work indicated that a chloroalkyl phosphate and a bromoalkyl phosphonate (5, 9) should show three to five times the effectiveness of the triaryl phosphates. The triaryl phosphates performed much better in rigorous field tests, however, than in lower temperature laboratory evaluations. This fact emphasizes the point of Schuyten and coworkers (8, 9) mentioned previously, that the fire-retarding agent must be "present or produced from its precursor ------" at burning temperatures. Although

other properties such as good solubility in oils, low solubility in water, low vapor pressure at ambient temperatures, and relatively low toxicity were met successfully, the haloalkyl phosphorus compounds were not included in the program because of cost and marginal stability at treating temperatures in the presence of a small amount of water.

4) The desirability of a flame-controlling agent was indicated. Throughout the field test program, it was observed that the most persistent flaming always occurred in protected locations where entrapped heat could cause volatile materials to burn above the wood surface and away from the influence of the phosphate additive. Also, it was obvious that the use of an organic phosphate did not materially influence the intense initial flaming.

A summation of this early work indicated that the use of triaryl phosphates represented the best available solution to the trestle fire problem. However, better control of flaming combustion of hydrocarbon distillation products remained a challenging problem. The use of an additive that would combine the effect of phosphorus with that of halogenated materials was deemed desirable. Consequently, a re-examination of the problems associated with the use of halogens was undertaken.

Laboratory Testing

In regard to the concept of phosphorus-halogen combinations, two changes in approach were made. First, it was decided that the triaryl phosphates are the most practical source of phosphorus. Accordingly, the new study dealt primarily with the selection of stable halogen compounds for use in conjunction with phosphate esters. Such a procedure is advantageous, since it allows selection of compounds with optimum properties, and through the use of separate compounds, phosphorus-halogen ratios can be varied as needed. The second change involved the establishment of a fire test method to yield results in agreement with field experience. Specimens for use in the new test were prepared by pressure impregnating ¾ inch by ¾ inch by 3 inch southern yellow pine blocks to desired retentions with various solutions. The blocks were then conditioned at 80°F. and 65 percent relative humidity.

Actual fire testing was carried out by suspending the specimens in the bore of a 1-¾ inch I.D. quartz tube heated by a vertically placed combustion furnace. The bottom of the tube was closed to eliminate up-drafts. A pilot flame at the top of the tube ignited combustible gases from the block. When the block was removed from the heat zone, it was placed on end in a draft-free area and allowed to burn without interference. The severity of the test is controlled by modifying the temperature of the furnace and the time period the specimens are allowed to remain in the tube. Observations of burning times and weight losses were recorded.

Many compounds were considered, screened for properties as previously mentioned, and subjected to the furnace test. Pentachlorophenol as a source of chlorine, and 2,4,6-tribromoaniline as a source of bromine, were selected for further development. The performance of these materials in studies of optimum phosphorus-halogen ratios in the furnace test is presented in Figs. 6 and 7. For this test, blocks were treated to retentions of approximately 30 pounds per cubic foot with creosote-petroleum solutions that contained the various fire retardants. The phosphorus in each case was present as triaryl phosphate. An exposure time of 20 seconds at 1200°F. was used in the combustion furnace. Specifications of oil and creosote used are found in Tables 2 and 4.

The data from which Figs. 6 and 7 were prepared leave little doubt about the potential value of combining halogens with phosphates. The question, however, was whether, as a practical matter, sufficient halogen could be incorporated into large treated structures to influence appreciably the great mass of volatile combustibles present. To answer this and other questions, a crib-type field test was devised and carried out by The Dow Chemical Company.

Table 1.—EFFECT OF WEATHERING ON WEIGHT LOSS OF PANELS IN PANEL FIRE TEST [1]

Composition of Treating Solution	Panel weight loss, lbs./sq. ft. of area burned Weathering period		
	1 Week	7 Months	23 Months
50:50 Creosote[3]—Seguro oil[2]	0.53	0.44	0.57
Same plus 0.95% phosphorus[4]	.33	.33	.33
5% Pentachlorophenol in 102 oil[2]	1.64	.31	.25
Same plus 0.95% phosphorus[4]	.51	.30	.14

[1]Cooperative test by The Dow Chemical Company and Atchison, Topeka and Santa Fe Railway. Weathering tests made at Albuquerque, New Mexico.
[2]See Tables 2 and 3 for oil analysis.
[3]Medium residue creosote.
[4]As triaryl phosphate.

Field Tests

Test Method: Incised Douglas-fir 4 by 4's, 5 feet long, were pressure treated to specified retentions. The 5-foot lengths were cut to produce two 30 inch pieces, which were used to construct cribs 10 tiers high as shown in Figs. 10 through 13. The two members in each tier were placed 10 inches apart, thereby producing a square central opening, which served to increase the severity of the test by acting as a flue.

Although screens were used to minimize wind effect, no tests were run

Table 2.—TYPICAL SPECIFICATIONS OF SEGURO OIL USED IN TRESTLE REPLICA AND PANEL TESTS

Distillation (corrected for elevation)	
Up to 315° C	4.8%
315–355	12.6%
Residue	82.0%
Loss	0.6%
Specific gravity 100/60° F	0.962
Water	0.5%
Flash point PMCC	115.5° C
PMOC	163° C

Table 3.—TYPICAL SPECIFICATIONS OF 102 OIL USED IN PANEL TESTS

Distillation	
Initial	225° C
5%	235
10%	238
20%	242
30%	244
40%	249
50%	253
60%	259
70%	264
80%	272
90%	284
95%	297
Maximum temperature	320
% Recovery	98
Flash Point PMOC	96° C
API gravity	30.4
Water	0.5%

Table 4.—SPECIFICATIONS OF MEDIUM-RESIDUE CREOSOTE USED IN LABORATORY FURNACE TESTS AND CRIB TESTS

Analysis by AWPA methods:		
Distillation		
Temp. °C		% in Cut
Up to 210		2.401
210–235		6.969
235–270		20.99
270–315		23.12
315–355		22.68
Residue		23.20
% Recovered	99.35	
% Coke residue		0.82
% Benzol insoluble		0.03
Specific gravity, 38/38°C.		1.0764
% Water, by volume		0.025

Table 5.—SPECIFICATION OF 101 OIL USED IN CRIB TESTS

Boiling range, Volume in Ml.:	°C. 10 mm.	°C. 760 mm.
First drop	109.0	266
2½	126.0	283
5	135.0	288
10	143.0	296
20	163.0	313
30	177.0	326
40	189.0	337[1]
50	196.0	345[1]
60	201.0	351[1]
70	211.0	362[1]
80	222.0	372[1]
90	242.0	396[1]
95	256.0	412[1]
97.5		
Dry point	282.0	444[1]
Recovery (Ml):		
as distillate	94.0	
as residue	1.0	
90% range °C.	121.0	
Flash point, °C. (Cleveland open cup)		157
Specific gravity, 15.6/15.6°C.		1.0123
Viscosity at 82°C. in Saybolt Fural Seconds		9.4

[1]Converted from boiling point at 10 mm. Only about 39 percent by volume will distil at atmospheric pressure.

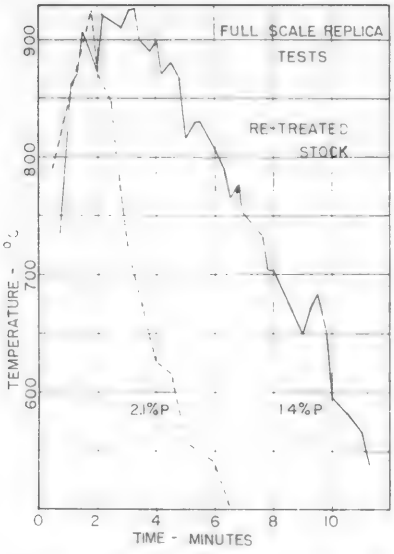


Fig. 5.—Time-temperature curves for full-scale trestle replica tests on Douglas-fir stock retreated with creosote-petroleum mixture containing 1.4 and 2.1 percent of phosphorus as triaryl phosphate to obtain 0.10 and 0.14 pound of phosphorus per cubic foot, respectively, in the outer ¼ inch.

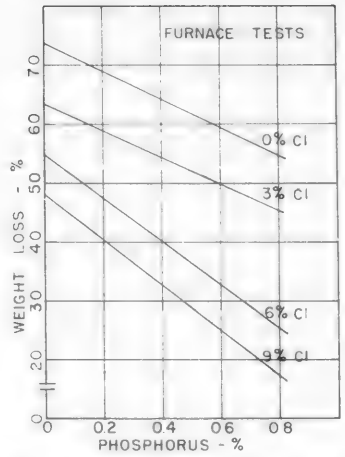


Fig. 6.—Combustion furnace test, showing effect of chlorine (as pentachlorophenol) on the weight loss of southern pine blocks treated with a 50:50 creosote-oil mixture containing various amounts of phosphorus (as triaryl phosphate).

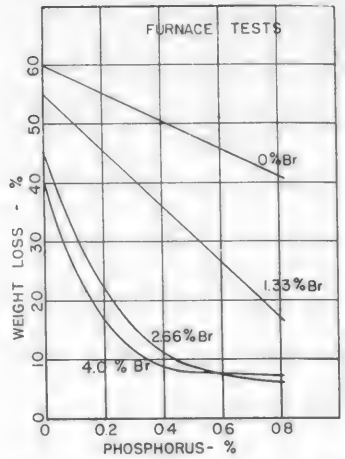


Fig. 7.—Combustion furnace tests showing effect of bromine as 2,4,6-tribromoaniline on the weight loss of southern pine blocks treated with a 50:50 creosote-oil mixture containing various amount of phosphorus (as triaryl phosphate).

when wind velocities exceeded 10 mph. Each crib was ignited with 200 ml. of gasoline placed in a 9-inch-diameter pan and centered under the structure. Temperature records were kept throughout each test by means of a thermocouple located centrally in the crib. Total crib weights were taken before and after the fires to provide weight—loss data. Total burning time and the rate of flame spread through the structure were observed.

Effect of Halogen: Two basic systems were studied. The first of these was based on medium-residue creosote (see Table 4 for specifications of creosote used) as a carrier, and compared the performance of triaryl phosphate additions with those of 2,4,6-tribromoaniline and the bromine-phosphorus combination. The time-temperature relationships for selected tests from this series appears in Fig. 8. Members of these cribs were treated by the full-scale method to approximately 19 pounds of treating solution per cubic foot of wood.

The second basic system investigated involved a high-boiling petroleum that contained pentacholorphenol-triaryl-phosphate mixtures. (See Table 5 for specification of 101 oil used.) Fig. 9 presents a portion of the time-temperature data from this series. Members of these cribs were treated by the full-cell method to approximately 18 pounds of treating solution per cubic foot of wood.

A comparison of Figs. 8 and 9 with Fig. 5 shows that the crib fires are somewhat more severe with respect to prolonged conditions of elevated temperature than is the full-scale replica test. Since both halogen compounds performed exceptionally well in the crib test, they must be regarded as contributing materially to over-all fire protection. Furthermore, the tests pictured in Figs. 10 through 13 suggest that the major contribution of the halogens is their effect of flame-spread characteristics. This had been difficult to confirm in early test work.

Effect of Retention of Preservatives: In early work by the panel test, it was noted that little fire hazard existed with timbers that contained no oil. The panel test on effect of volatility of oil described earlier in the paper indicates that higher retentions of petroleum increase the hazard. Data in Table 1 indicate that, as petroleum is

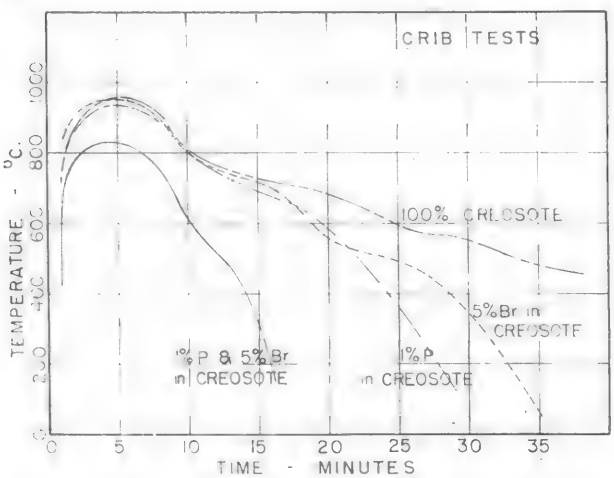


Fig. 8.—Effect of phosphorus (as triaryl phosphate) and bromine (as 2,4,6-tribromoaniline) in creosote on the time-temperature relationship during burning of cribs constructed with twenty 2-foot, 6-inch pieces of Douglas-fir incised 4 by 4's treated to 19 pounds of total solution per cubic foot.

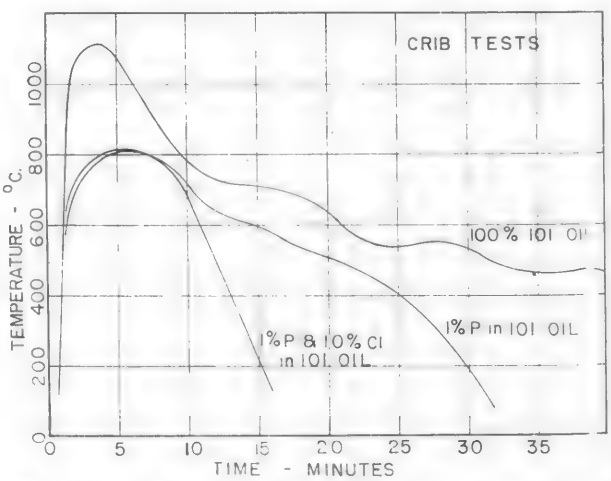


Fig. 9.—Effect of phosphorus (as triaryl phosphate) and chlorine (as pentachlorophenol) in 101 Oil on the time-temperature relationship during burning of cribs constructed with twenty 2-foot, 6-inch pieces of Douglas-fir incised 4 by 4's treated to 18 pounds of total solution per cubic foot.

'ost through weathering, the hazard to the controls that contain oil but no fire retardant may materially decrease. To obtain a better idea of the hazard caused by increased retention, a series of crib tests were conducted.

For this series, treatments of 1 per ent phosphorus as triaryl phosphate in creosote were made to retentions of 9, 2, and 19 pounds per cubic foot. (See Table 4 for creosote specifications.) The 9- and 12-pound-per-cubic-foot retentions were obtained by empty-cell treatment and the 19-pounds retention by full-cell treatment.

Fig. 14 shows the time-temperature relationship found in this study. The idea that large retentions of oil-type preservatives cause increased fire hazard appears valid, since the time required for the temperature to fall below 200°C. for the 19-pound treatment is 3 times that of the 9-pound treatment.

It is evident that it may be necessary to increase the ratio of fire retardant to oil as the total oil retention is increased. This remains a problem.

Conclusions

1. The most effective treatment for reducing the fire hazard associated with wood trestles treated with oil-type preservatives is a phosphorus-halogen mixture added in proper ratio.

2. Phosphorus as triaryl phosphate contributes materially to reduction of the fire hazard.

3. Halogen specifically reduces flame spread, and thus contributes to reduction of the over-all hazard. Pentachlorophenol and 2,4,6-tribromoaniline appear to have properties that make them suitable as halogen carriers for this application.

4. High retentions of oil-type preservatives create a greater fire hazard than do low retentions. Increased percentages of phosphorus and halogen in the treating solution may be indicated for the higher retentions.

5. Further work on effect of type of treatments, species, ratios of fire retardant to oil for given retentions, and on many other problems is indicated.

6. Test methods must be selected on the basis of problems involved. The correlation of laboratory and field test data is extremely critical.

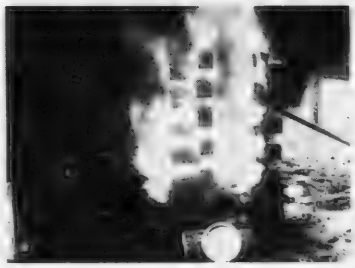


Fig. 10—Crib test one minute after ignition. Douglas-fir incised 4 by 4's treated to 19 pounds of creosote per cubic foot.

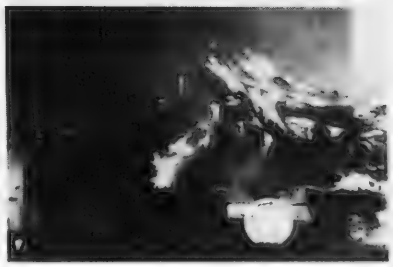


Fig. 11.—Same crib test as in Fig. 10, 73 minutes after ignition.

Fig. 12.—Crib test one minute after ignition. Douglas-fir incised 4 by 4's treated to 19 pounds per cubic foot with creosote solution containing 1 percent phosphorus as triaryl phosphate and 5 percent bromine as 2,4,6-tribromoaniline.

Fig. 13.—Same crib test as in Fig. 12, 16 minutes after ignition.

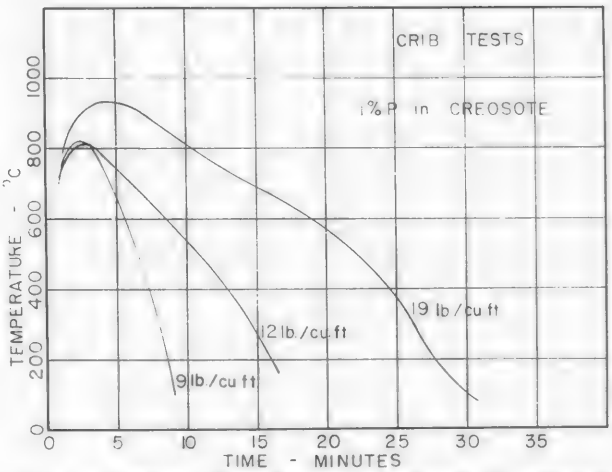


Fig. 14.—Effect of retention of treating solution of phosphorus in creosote on the time-temperature relationship during the burning of cribs constructed with twenty 2-foot, 6-inch pieces of Douglas-fir incised 4 by 4's. Phosphorus present as triaryl phosphate.

Literature Cited

1. Belles, F. E. 1955. Chemical action of halogenated agents in fire extinguishing. National Advisory Committee for Aeronautics. Tech. Notes 3565.
2. Browne, F. L. 1958. Theories of the combustion of wood and its control. Forest Prod. Lab., Report 2136.
3. Church, J. M., R. W. Little, and S. Coppick. 1950 Evaluation of flame-resistant fabrics. Ind. and Eng. Chem. 42: 418.
4. Cleary, L. T. 1954. Fire retardant investigation of phosphorylated amino ethyl cellulose structures. Ph.D. Thesis, Columbia Univ.
5. Erbel, A. J., and D. L. Kenaga. 1957. U.S. Patent 2,803,562.
6. Freedman, R., and J. B. Levy. 1957. Survey of fundamental knowledge of mechanisms of action of flame-extinguishing agents. Wright Air Development Center Tech. Report 56–568.
7. Fryburg, G. 1950. Review of literature pertinent to fire-extinguishing agents and to basic mechanisms involved in their action. National Advisory Committee for Aeronautics. Tech. Note 2102.
8. Hubert, E. E. 1952. The use of fire retardants in a penta fence post preservative. Research Note No. 2, Forest, Wildlife and Range Experiment Station, Univ. of Idaho.
9. Kenaga, D. L., and A. J. Erbel. 1955. U.S. Patent 2,725,311.
10. Little, R. W. 1951. Fundamentals of flame retardancy. Textile research Jour., December, 901–8.
11. Little, R. W. 1947. Flameproofing textile fabrics. ACS Monograph 104, Reinhold Pub. Corp.
12. Schuyten, H. A., J. W. Weaver and J. D. Reid. 1954. Some theoretical aspects of the flameproofing of cellulose. Advances in Chemistry Series No. 9.
13. Schuyten, H. A., J. W. Weaver and J. D. Reid. 1955. Effect of flameproofing agents on cotton cellulose. Ind. and Eng. Chem. 47 (7): 1433.

EFFECT OF FORMATION VARIABLES ON

Properties of Wood Particle Moldings[1,2]

T. J. PATTERSON
Georgia–Pacific Corp. Research Laboratory,
Hillsboro, Oregon

J. D. SNODGRASS
Oregon Forest Porducts Research Center,
Corvallis

Pressure had greatest overall effect on molding properties; resin content and moisture content were second and third. In many cases, moisture content could be varied rather than resin, to improve properties.

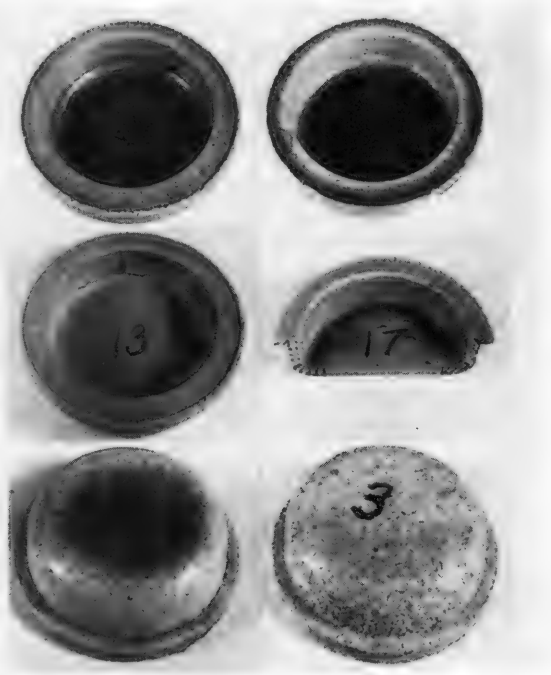


Fig. 1.—Molded cups with typical manufacturing defects as darkened areas (26, 31), ruptures (13, 17, 26), blister (6), and lack of flow (3).

MOLDINGS DISCUSSED HERE are articles with simple compound shapes formed of wood fragments bound with synthetic resin under considerable pressure. Both circular cup-shape and dish-shape moldings were made; the latter were far more successful than the former. Resin contents were lower, and particle sizes generally larger than used for the many well-known wood-filled, high-resin -content "plastic" products in everyday use. The compound curvative presented special problems in formation not encountered in manufacture of flat panels.

The Authors: T. J. Patterson holds a BSF degree in forestry from the University of British Columbia, and an MS from Oregon State College. He is a Quality Supervisor with Plywood Fabricator Service, Inc., Chicago, Ill.

J. D. Snodgrass, Associate Chief of Physical Research at the Oregon Lab, holds BS and MS degrees in wood technology from the University of Michigan, and later was associate professor of forest products at Oregon State.

The formation, properties, and characteristics of moldings (if this term is given broad interpretation) in flat panels have been the object of great interest. Such particle boards, as they properly are called, have appeared in abundance. Technology of their manufacture and use, already well-founded, grows steadily.

Shaped moldings formed of materials roughly similar to ingredients in the nonflake-type particle boards are uncommon. The possibilities in their manufacture have been given less attention in technical literature than that given their flat-panel companions. Midyette (6)[3] recently discussed properties of flat disk-like moldings formed of 80–100 mesh wood particles sprayed with a liquid synthetic resin and pressed under heat and pressure. Earlier, Burkhart (1) and others (7) (13) described wood particle moldings, including experimental molded gun-stocks produced in Austria during World War I. Cooke (2), Macdonald (5), and Smith (9) discussed products molded or consolidated from wood particles in literature published during 1948–50. Cooke listed 26 shaped articles that were, or possibly could be, formed of resin-bound consolidated wood particles.

Except for Midyette's contribution, most of the authors named wrote in general terms about wood moldings. Others, however, have described specific experiments designed to establish relationships among various key variables in forming, such as resin content, moisture content of the molding mixture, pressure, temperature, and particle size. Influences of these controllable conditions, singly and in simple combinations, on various product properties such as strength, density, and water absorption have been discussed to some extent. Sears (8) reported on his work in 1950. Turner (10), and Turner and Kern (11) studied particle size in relation to strength and dimensional stability of consolidated panels and influences of some formation variables on properties of wood particle boards. Gottstein (4) in 1950, and Williams and Grano (12) in 1954

[1] Presented at Session XVIII, General, FPRS 13th National Meeting, June 28-July 3, 1959 in San Francisco.

[2] Based on the senior author's thesis presented in October, 1957, at Oregon State College in partial fulfillment of the degree of Master of Science.

[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

also reported on experiments that involved manipulation of formation variables and resulting properties of consolidated woodbase products. Past work and general experience show clearly that formation variables interact in favorable and, sometimes, unfavorable ways to establish properties of the finished product.

Though a number of previous workers performed comprehensive experiments involving formation variables, there has been, for obvious reasons, a concentration of interest in flat-panel products and simple combinations of variable factors. The present experiment was planned to examine simultaneously several formation variables during limited production of a small, wood-base article of some compound curvature. Objectives were to determine influence of variables on certain physical properties of the articles, to decide possibility of producing such moldings from certain combinations of materials, and to gather general insight on some production problems.

The general plan of approach was to perform a preliminary and a main experiment. Both steps presented problems and yielded interesting information. Preliminary trials were exploratory to establish conditions for the main experiment. The main project was a 3 by 3 by 3 by 3 factorial experiment in randonmized blocks (technically, a split-plot type) with 4 replications. Essential details on experimental variables are given in Table 1. Research was at the Forest Products Research Center in cooperation with the School of Forestry, Oregon State College.

Exploratory Studies

Detailed studies were made on production variables to establish conditions for a factorial experiment. Main factors were shape of die, moisture content of molding mixture, pressure for molding, and testing procedures. Subsidiary considerations were resin mixing, distribution of resin on particles, and particle size.

A cup-shape die with a right-angle bend and a curve with radius of one-quarter inch was chosen to evaluate flow characteristics under difficult conditions. All moldings from the cup-shape die had defects (Fig. 1). Bottom and lip had high density, vertical walls had low density, and, at the junctures, fractures formed that were not eliminated by preforming or change of pressure.

A simple dish-shape molding increased uniformity of density and eliminated fractures, but strength was low with large particles (10–20 mesh) and low resin content (5 percent powdered phenol-formaldehyde).

Fig. 2.—Mold parts for dish-shape die: bottom row, left to right, preform plug, female die and chase. Chase extension is on top of the hot plate.

Flow was improved by increasing resin content, decreasing particle size, and by granular rather than stick-shape particles. Preforming, and momentary releases of pressure during pressing, resulted in successful moldings from mixtures with as high as 24 percent moisture content. Pressures tried ranged from 200 to 1500 pounds per square inch of projected area. High pressures and preforming resulted in elimination of voids.

Trials of various test procedures led to choice of three standard tests and one designed arbitrarily to provide a measure of strength: Rockwell Superficial Hardness (ASTM Standard E18-57), water absorption in 2 and in 24 hours, specific gravity (of 3 segments, see Fig. 4), and strength index.

Strength was difficult to test because of the curved shape of test pieces. Half of each molding was center-loaded as shown in Fig. 5. A strength index was obtained by dividing the breaking load, in pounds, by the square of the thickness of the bottom of the molding, in inches.

Main Experiment

Procedures followed in the final study included preparation of moldings, physical testing of them, and statistical analysis of results. Levels of variables used are listed in Table 1. Physical tests just described served to measure properties of the finished moldings.

Preparation of Moldings: Solid, unseasoned, Douglas-fir mill residue was picked at random from the waste conveyor at a local sawmill, and bark was removed. Bark-free wood was passed through a chipper, chip breaker, and chip screen, and the resulting chips were dried in a kiln to 6 percent moisture content. Chips were spread on a clean floor and thoroughly mixed.

Dried, mixed chips were reduced to particles by passing them through two hammer mills; a Gruendler mill with 3/16-inch screen, and then twice through a John Deere mill with a 3/32-inch screen. The product of this

Fig. 3.—Some molded dishes: left, fine particles; right, coarse particles.

milling was segregated by a Sweco vibrating-screen separator into coarse, medium, and fine particles: that is, 10–20, 20–40, and 40-pan mesh classes.

Each molding represented a different combination of particle size, resin content, moisture content, and pressure. Four such moldings, the 4 replicates were made for each of the 81 possible combinations (4 variables each at 3 levels).

Molding was done in an electrically heated Preco hydraulic press fitted with dish-shape dies previously described (Fig. 2). The charge was poured into the chase. An extension was placed on top of the chase to accomodate the hardwood preforming plug (Fig. 2), which was twisted back and forth several times to give the charge a shape similar to that of the finished molding. When preforming was complete, the extension of the chase and the hardwood preforming plug were removed, and the female die and chase were placed in the press.

During pressing it was necessary to "breathe" the dies to reduce danger of blister formation and blows. Dies were breathed 3 times during the 8-minute pressing cycle. As soon as full required pressure was attained, pressure was released for the first breathing period, and the press again was closed. Following one minute at required pressure, the second breathing was provided. Then, after 2 additional minutes at required pressure had elapsed, the last breathing period was allowed. Breathing let generated steam escape, and aggregated no more than a few seconds of the total pressing cycle.

To prevent particles from sticking to the die faces, the dies were polished with jeweler's rouge and periodically repolished and coated with silicone mold release. Also, 1 percent of zinc stearate, based on the oven-dry weight of the particles, was added to the molding mixture.

Testing the Moldings: The 324 finished moldings were sectioned for test as shown in Fig. 4. The 2 identical largest coupons were reserved, respectively, for the index of strength and water-absorption tests, and the central ¾-inch-wide strip, subdivided into 3 smaller pieces, was measured for specific gravity and Rockwell Superficial Hardness. Specific gravity was determined at 3 different positions in the diametrical ¾-inch strip: Position 1 was near the upper edge of the molding, position 2 was midway down the curved side of the molding, and position 3 was at the bottom of the molding. The test for Rockwell Superficial Hardness was performed only on specific gravity coupon 3.

Specimens to provide the index of strength and to be tested for water absorption were conditioned in a room maintained at 70°F. and 65 percent relative humidity (these conditions favor establishment of 12 percent moisture content in wood).

The bending test (Fig. 5) was conducted on a Tinius–Olsen, electromechanical, universal testing machine fitted with a Baldwin air cell. Load, applied at the rate of 0.01 inch per minute through a ⅜-inch-diameter test head secured to the air cell, was indicated on a Tate-Emery indicator with capacity from zero to 200 pounds. The breaking load was noted, and the index of strength was computed by dividing breaking load by the square of the thickness of the test piece at mid-span.

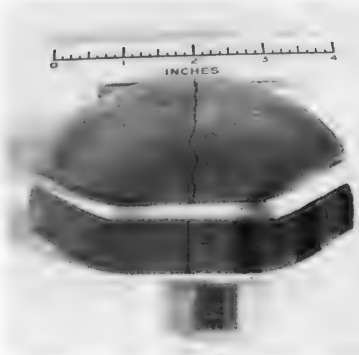


Fig. 4.—Test specimens cut from a dish-shape molding: upper part was for bending tests; ¾-inch center strip for specific gravity at positions 1, 2, and 3. Rockwell Superficial Hardness was measured on wafer 3, and water absorption on the part (not shown) comparable to the bending specimen.

Fig. 5.—Strength index was obtained from breaking load, in pounds, from the bending test shown, divided by the dish thickness, in inches squared, at midspan.

The 2- and 24-hour water-soak tests were conducted on previously conditioned coupons that were then immersed in water maintained at a constant temperature of 65°F. and a pH of 7.2. Water absorption was computed in percent, based on the original (conditioned) weight of the piece.

Specific gravities were determined by a conventional immersion procedure after specific gravity coupons had been oven-dried to constant weight. Since 3 measurements of specific gravity were made for each molding, there were 972 separate determinations of specific gravity.

The oven-dry specific gravity coupon from position 3 was used for hardness tests performed on a Rockwell tester with the indicator set to the "deep" position. Net indentation of a ½-inch ball, actuated by a 15-kilogram weight on the weight holder, was recorded. The indicator on the Rockwell machine is so arranged that the higher the reading, the smaller the net indentation made by the impressed ball.

Table 1. Manufacturing Conditions for Preliminary and Final Experiments Molding Wood Particles.

A. Conditions for preliminary experiments

Variable			
Particle size, mesh*	8-16 (coarse)	16-30 (medium)	30-60 (fine)
Resin content, per cent**	15	10	5 and 2.5
Moisture content, per cent**	15	10	5
Pressure, psi***	800	400	200
Constant			
Temperature, deg F	300	300	300
Press time, minutes	10	10	10

B. Conditions for final experiment

Variable			
Particle size, mesh*	10-20 (coarse)	20-40 (medium)	40-pan (fine)
Resin content, per cent**	15	10	5
Moisture content, per cent**	15	10	5
Pressure, psi***	1500	1000	500
Constant			
Temperature, deg F	325	325	325
Press time, minutes	8	8	8

* First number is mesh passed through; second number is retaining mesh.

** Based on oven-dry weight of wood.

*** Based on projected area.

Table 2. Mean Indicies of Bending Strength* of Moldings Made with 81 Combinations of Formation Variables.

Moisture content	Pressure	Resin content, per cent 5	10	15
Per cent	Psi			
Large particles, 10-20 mesh				
5	500	236.6	401.9	606.1
	1000	545.4	956.7	1233.2
	1500	955.9	1537.2	1851.0
10	500	280.7	611.6	873.9
	1000	880.5	1234.2	1888.9
	1500	1317.7	1961.6	2468.3
15	500	412.0	817.0	1000.2
	1000	903.1	1720.3	1807.6
	1500	1719.9	2258.0	2615.0
Medium particles, 20-40 mesh				
5	500	242.8	404.5	650.9
	1000	531.6	879.1	1410.2
	1500	686.7	1433.0	2178.5
10	500	345.7	739.5	978.0
	1000	778.7	1245.8	1871.7
	1500	1203.6	2048.7	2618.7
15	500	615.4	761.4	1328.9
	1000	997.0	1806.1	2356.7
	1500	1475.0	2165.8	2583.1
Small particles, 40-pan mesh				
5	500	280.0	877.8	678.5
	1000	613.4	1216.8	1569.1
	1500	1025.0	1589.9	2143.7
10	500	614.2	623.3	1155.2
	1000	987.6	1502.8	1859.4
	1500	1327.7	1974.9	2647.6
15	500	497.9	1106.7	1573.5
	1000	1401.1	2294.0	2402.9
	1500	1857.8	2372.8	2574.7

* Arbitrary index of strength was breaking load, in pounds, divided by square of thickness, in inches.

When all tests had been completed, a total of 2,268 observations were recorded. These data were analyzed statistically as described in following paragraphs.

Statistical Analysis and Results: Analyses of variance, not given in detail here, were made for each property tested. There were five such analyses. Significance of the four main effects (particle size, resin and moisture contents, and pressure) and the various interactions were determined for each property measured. The analysis of variance for specific gravity included, in addition to the four formation variables, position of specific gravity wafer as a variable factor. Data, in the form of means for each property (results for 2-hour water absorption excepted) are given in Tables 2 through 5. Mean values of specific gravity shown in Table 4 are those for position 1 only, but position was not considered in Table 6. A general summary of statistical significances is given in Table 7 for main effects and interactions.

Because of the intricacy and usefulness of a factorial experiment, many forms of graphical presentation with data displayed in various arrangements might be made. As examples, Figs. 6 and 7 were prepared to illustrate the influence of selected variables on specific gravity (at position 1, Fig 6) and strength (Fig. 7). From the means given in Tables 2 to 5, other arrangements can be constructed by the interested reader.

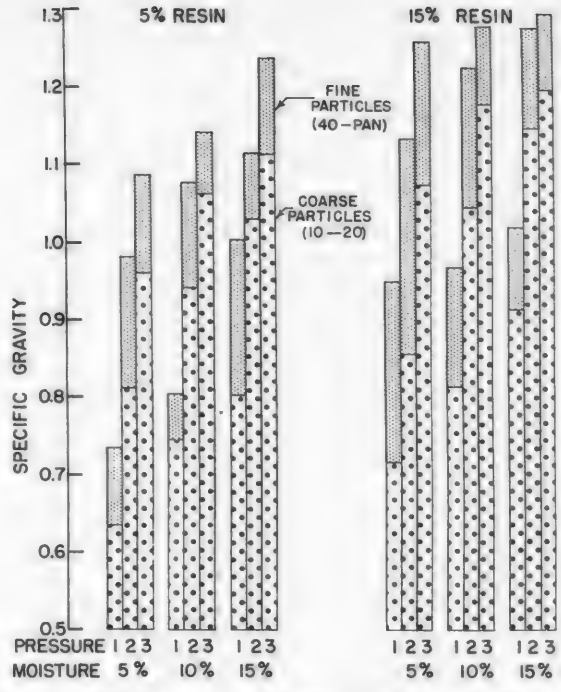


Fig. 6.—Specific gravity (at position 1) of moldings made with coarse and fine wood particles, 2 resin contents and 3 moisture contents, and at pressure levels 1, 2, and 3 (500, 1000, 1500 pounds).

Discussion

Results (Table 7) from the 5 analyses of variance indicated all main effects influenced physical properties significantly at the 1 percent level of probability; that is to say, were highly significant, except for effect of particle size on bending strength, which was not statistically significant. Location of specific gravity coupon also proved highly significant, as did the four first-order interactions, which involved all main effects, and coupon location, on specific garvity. Of the other 25 second-order interactions, 11 were highly significant, two were significant (5 per cent probability level) and the others not significant. Four of 15 third-order interactions were highly significant, 3 were significant, and 8 were not significant.

Differences between the means in Tables 2 to 5 are not significant, but various separate averages can be prepared for each level of each variable where all effects but the one under rutiny are averaged out. Bending rength, for example, was influenced gnificantly by resin and moisture conents, and pressure; particle size by itself did not influence this property. When the special averages just mentioned were prepared (Table 6), bending strength had greatest increase where the variables, except for particle size, were changed from the lowest to middle magnitude. The third step-up of variables caused relatively less, but, of course, some additional increase in bending strength. A maximum bending-strength index of 1874 was achieved with 1500 psi molding pressure, when all the effects of all other variables were averaged out. Resin content of 15 percent was secondarily influential and resulted in a bending-strength index of 1738 under comparable conditions. Third in order of importance came moisture content of 15 percent, which, in combination with all levels of other variables, caused moldings to have a strength index of 1608.

The above discussion shows the strength of moldings was increased by increasing any one of the three significant variables. When Tables 2 and 6 are examined, one can see that, if moisture content and resin content were held constant and pressure was increased, pronounced increases in strength would take place. By holding moisture content and pressure constant, and increasing resin content, changes in strength take place about equal to increases created when resin content and pressure are held contant and moisture content is increased. Since particle size and its interactions with the other three variables were not significant, no comparison need be made.

For brevity, only results of the 24-hour water-soak test are given (Table 3). Fairly constant relationship between absorption in 2- and 24-hour periods seemed to hold, however. The lowest absorption in 24 hours was 7.62 percent (smallest particles, highest resin and moisture contents), and in 2 hours these moldings had absorbed 2.1 percent, or about 28 percent of the total absorbed. The comparable relationship for the most absorptive molding, based on 24-hour performance, was 15.55 and 59.08 percent, or about 26 percent of the total in the first 2. It seemed that 24-hour absorption might be predicted from 2-hour performances with reasonably close and consistent accuracy.

Means were calculated for the three levels of each main factor from the data in Table 3. Moisture absorbed by moldings decreased as particle size decreased and as resin content, moisture content, and pressure increased (Table 6). The difference between the first and second level of the variables showed the greatest reduction in water absorption in all instances except that of moisture content. Here, the difference between the second and third level was the larger of the two. Resin content of 15 percent permitted absorption of about 18 percent moisture, the smallest amount. Pressure of 1500 psi promoted about 21 percent water absorption. Third in order of importance was moisture content, where the 15 percent level resulted in moldings that averaged 21.8 percent moisture ab-

sorption. Particle size was least influential: size 40-pan particles resulted in moldings that averaged 22.9 percent water absorption.

All variables influenced hardness in a highly significant way. The significant and highly significant interactions are shown in Table 7. Again, means were calculated for the three levels of each main factor from the data of Table 5 to permit examination of the influence of main variables that operate independently (see Table 6). With respect to hardness, a pressure of 1500 psi produced the hardest surface, 71.6; particle size of 40-pan was second where hardness was 65.6 resin content of 15 percent was third and caused a hardness of 64.6; and moisture content of 15 percent was fourth with hardness of 61.7. Hardness of moldings increased, therefore, as particle size was decreased and as resin and moisture contents and pressure were increased.

An interesting observation was that the greatest increase in hardness occurred between levels 1 and 2 for resin content and pressure. The greatest increase in hardness occurred between levels 2 and 3 for particle size and moisture content. Examination of Table 5 reveals that a rather broad range of values for Rockwell Superficial Hardness resulted; the lowest was -7.25, while the greatest was 87.88.

Mean specific gravities for position 1 only (Table 4) of moldings from all 81 combinations of formation variables are given here, but complete additional sets of means also were prepared for positions 2 and 3. Specific gravities for position 1 were the highest and position 3 lowest, except for 9 of 81 instances where position 2 specific gravities were lowest. Specific gravities for position 2 generally were intermediate between the others. The very highest specific gravity was 1.293 and the lowest was 0.547. The highest levels of resin content, moisture content and pressure and smallest particles, were consolidated to the greatest density, as would be expected, while the lowest levels of resin content, moisture content and pressure, and coarse-size particles gave the lightest moldings. No particular order of differences between high and low specific gravities within moldings was evident. Highest varied from lowest specific gravity within various moldings by as much as 0.3 to 0.4 for dense ones, to as little as 0.03 to 0.04 for the relatively light ones.

The original thought was that performing would eliminate most of the variation in density within moldings. This was not true. At the highest levels of resin and moisture contents and pressure, and the smallest particle size, the greatest differences in specific gravity within a molding were found to occur. Perhaps this was caused by a migration of moisture in the form of steam or softened resin toward the outer lip of the molding during the breathing periods when steam was allowed to escape.

As for the other properties, specific gravity means were calculated for the three levels of each main factor (Table 6) from specific gravity data similar to that in Table 4. A comparison of variables showed that pressure influenced specific gravity most; a pressure of 1500 psi resulted in moldings of average specific gravity 1.068. Moisture content was secondarily influential, where the 15 percent level resulted in average specific gravity of 1.015. Particle size was third, with 40-pan particles giving specific gravity of 0.993, and resin content of 15 per cent was fourth, giving specific gravity of 0.986.

Specific gravity increased as particle size decreased, and as resin and moisture contents and the pressure increased. Specific gravity decreased as the position changed from the outer edges to the center of the moldings. Increase in magnitude of resin and moisture contents and pressure from the first to the second level caused the greatest change in specific gravity. Change in specific gravity was greatest between second and third levels for pressure and position.

Resin content acted alone to influence specific gravity, and did not interact with variables other than position. Particle size and moisture content each interacted with pressure. Resistance to compression evidently was reduced be-

Table 3. Water Absorption in 24-hour Soak of Moldings Made with 81 Combinations of Formation Variables.

Moisture content	Pressure	Resin content, per cent 5	10	15
Per cent	Psi	%	%	%
Large particles, 10-20 mesh				
5	500	55.8	41.0	31.6
	1000	54.1	35.7	23.5
	1500	50.4	30.6	20.7
10	500	59.1	39.6	29.1
	1000	50.7	29.3	21.3
	1500	40.1	21.7	16.3
15	500	49.8	35.8	28.5
	1000	39.6	26.5	18.6
	1500	28.3	18.5	11.5
Medium particles, 20-40 mesh				
5	500	56.5	31.5	25.3
	1000	50.8	29.5	20.7
	1500	44.7	24.4	14.4
10	500	50.0	28.7	23.2
	1000	42.7	24.2	17.9
	1500	30.4	17.3	12.3
15	500	40.6	24.4	19.6
	1000	27.9	16.9	13.2
	1500	18.8	12.1	11.0
Small particles, 40-pan mesh				
5	500	54.9	41.3	24.0
	1000	44.1	22.4	16.4
	1500	33.3	16.6	11.0
10	500	45.8	30.2	22.1
	1000	34.8	17.3	11.1
	1500	23.0	14.1	9.5
15	500	33.2	20.6	15.8
	1000	20.5	12.2	9.4
	1500	16.9	10.9	7.6

Table 4. Specific Gravities, for Position 1, of Moldings Made with 81 Combinations of Formation Variables.

Moisture content	Pressure	Resin content, per cent 5	10	15
Per cent	Psi			
Large particles, 10-20 mesh				
5	500	0.635	0.673	0.715
	1000	0.823	0.854	0.856
	1500	0.960	0.990	1.074
10	500	0.746	0.735	0.831
	1000	0.942	0.988	1.044
	1500	1.061	1.059	1.177
15	500	0.804	0.860	0.912
	1000	1.040	1.071	1.146
	1500	1.119	1.193	1.194
Medium particles, 20-40 mesh				
5	500	0.693	0.766	0.836
	1000	0.876	0.922	0.988
	1500	0.983	1.075	1.144
10	500	0.779	0.837	0.866
	1000	0.952	1.013	1.199
	1500	1.100	1.156	1.129
15	500	0.901	0.918	1.019
	1000	1.093	1.144	1.182
	1500	1.176	1.230	1.249
Small particles, 40-pan mesh				
5	500	0.736	0.872	0.950
	1000	0.982	1.077	1.131
	1500	1.088	1.165	1.256
10	500	0.804	0.904	0.967
	1000	1.079	1.128	1.223
	1500	1.142	1.217	1.277
15	500	1.002	1.004	1.016
	1000	1.155	1.188	1.275
	1500	1.237	1.268	1.293

ause of a plasticizing effect of moisture, while the larger the particle size the greater must have been the void spaces, together with increased resistance to compressive forces during molding. Particle size and moisture reacted together, since the moisture present under conditions of heat and pressure should reduce the ability of particles to resist compressive forces.

In summary, changes in properties of the moldings as the magnitude of production variables changed was as follows: Bending strength, specific gravity, and hardness increased, while moisture absorption decreased, when particle size decreased and resin content, moisture content, and pressure increased. This statement does not mean that the smallest particle size, the highest resin and moisture contents, and highest pressure unite to infleunce the various properties in such a way as to produce the best result. This is shown by results for the fourth-order interaction in Table 6: the interaction of particle size, resin content, moisture content, and pressure was significant in only 1 of 5 instances. Apparently, therefore, production variables that act primarily alone cause the various changes in properties described above.

Since developing an intuitive feeling for results couched primarily in statistical language is difficult, Figs. 6 and 7 were prepared to illustrate some results graphically. Specific gravity means from Table 4 were plotted in Fig. 6 with emphasis on moldings made from coarse and fine particles. Results in general for moldings made of medium-sized particles would be intermediate between those shown. The same could be said for the intermediate resin content, 10 percent, which has been omitted in constructing the figure.

Relationships of strength index to specific gravity shown in Fig. 7 are based on specific gravity values for position 3 and strength indices from Table 2. Position 3 specific gravities were generally the lowest; Fig. 7, therefore, is a moderate rating of relationships between strength index and specific gravity. For simplicity's sake, a number of levels of variables were omitted in Fig. 7, but the curves shown make possible an understanding of where other curves for variables not shown would lie. There seems to be a generally curvalinear pattern to the relationship of strength index to specifix gravity; statistical tests for this possibility, however, were not made. As would be expected, curves that represent 15 percent resin content lie somewhat above those for 5 percent resin content. Note, too, that moisture content seemed to play an important part with respect to specific gravity of

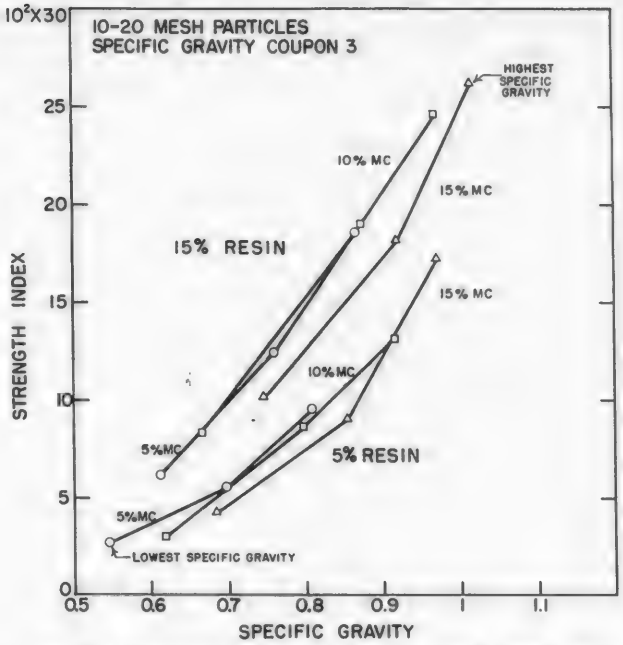


Fig. 7.—Relationship of strength index to specific gravity (position 3) of moldings from coarse wood particles (10–20 mesh) by 3 pressures, 2 resin contents and 3 moisture contents.

molded articles, irrespective of the resin content involved.

Conclusions

Preliminary Experiment: Within the limits of the variables studied in this experiment, the following conclusions were reached about the influence of variable factors on properties of wood-particle moldings.

Unless some form of an expanding die or a bag-molding technique is used, pressure will not be equal and normal to all surfaces of a molding of complex shape. Uniform pressure is required if uniformity of the product is to be achieved at resin contents as low as 15 percent.

Resin content must be increased above that used for simple shapes to prevent voids from developing when the shape to be molded is complex. To make complex shapes while using a low resin content, a preform must be chosen that closely matches the finished molding. With this type of molding compound, the flow at best was limited and was dependent more on particle size and shape than on resin content. The greatest flow was produced by high resin content and small particle size, while the least flow was produced by low resin content and large particles.

The belief was that only wood particles of low moisture content could be used for this type of molding to avoid blistering the molding at the high pressures and temperatures involved in the molding procedure. Preliminary experiments showed that, through proper preforming and breathing of the molding, low- and high-density spots as well as water marks and blisters could be eliminated. By this means, blister-free moldings were made from wood particles at moisture contents as high as 24 percent.

The particle size than can be used successfully to make moldings varies as the complexity of the shape to be produced. Very coarse particles (6-mesh) can be used if the particle shape is granular rather than stick-like and if a simple shape is made. Fine wood particles must be used with complex shapes.

By preforming, it is possible to increase uniformity of density throughout the molding over a rather wide range of resin-content and particle-size combinations. Preforming also makes it possible to vary the specific gravity from place to place in the molding. Thus, the molding can be strengthened at critical points if this is desired.

Blisters resulted when the molding mix produced a large amount of vapors that were trapped effectively in the mold, either through high pressure or through the shape of the dies. Unless a breathing technique is used, blisters will develop with high pressures, high moisture contents, high natural volatile content of the wood, and high synthetic resin contents.

Main Experiment: Pressure exerted on the molding mix in heated dies had a highly significant effect on bending strength, water absorption, specific gravity, and superficial hard-

Table 5. Rockwell Superficial Hardness of Moldings Made with 81 Combinations of Formation Variables.

Moisture content	Pressure	Resin content, per cent 5	10	15
Per cent	Psi			
Large particles, 10-20 mesh				
5	500	-7.3	13.3	19.1
	1000	32.9	47.9	55.8
	1500	50.4	58.6	76.8
10	500	-0.4	17.0	38.8
	1000	44.9	56.9	62.0
	1500	60.9	68.5	70.6
15	500	23.8	26.9	41.3
	1000	56.1	60.4	60.4
	1500	61.3	68.0	79.4
Medium particles, 20-40 mesh				
5	500	11.6	24.9	36.1
	1000	49.9	53.9	65.9
	1500	49.1	68.5	78.1
10	500	16.9	34.0	40.6
	1000	44.8	54.9	70.0
	1500	64.3	70.5	82.4
15	500	41.4	43.1	48.3
	1000	61.0	69.6	73.8
	1500	68.6	67.5	78.0
Small particles, 40-pan mesh				
5	500	16.0	48.8	54.9
	1000	53.0	70.5	80.5
	1500	69.6	78.9	85.3
10	500	18.9	50.0	54.0
	1000	65.5	72.5	81.8
	1500	69.0	79.4	87.9
15	500	41.4	62.5	54.6
	1000	70.4	80.6	84.9
	1500	78.6	83.1	82.0

Table 6. Means for Each of 4 Physical Properties as Influenced by Individual Formation Variables.

Particle size* Coarse	Med.	Fine	Resin content, % 5	10	15	Moisture, % 5	10	15	Pressure, psi 500	1000	1500
Strength Index											
Not significant			842	1353	1738	990	1335	1608	693	1366	1874
Water absorption in 24 hours, per cent											
33.6	27.0	22.9	40.6	24.9	17.9	33.5	28.2	21.8	35.5	27.1	21.
Rockwell Superficial Hardness**											
46.1	54.4	65.6	44.8	56.7	64.6	49.6	54.7	61.7	32.2	62.2	71.
Specific gravity***											
0.90†	0.93†	0.99	0.89	0.95	0.99	0.86	0.95	1.02	0.78	0.97	1.0

* Coarse, 10-20 mesh; medium, 20-40 mesh; fine, 40-pan mesh.
** With 1/2-inch steel indenter and 15-Kg weight; see ASTM Std E18-57.
*** Means for position of coupon have been omitted.
† All other values listed were significantly different at the 5 per cent level of probability; most were significantly different beyond the one per cent level.

Table 7. Statistical Significance for Formation Variables and Their Interactions.

Variables*	Physical Property: Strength index	Water absorption 2-hour	24-hour	Sp. gravity	Rock. Super. Hard.
Main effects					
PS	N**	HS	HS	HS	HS
R	HS	HS	HS	HS	HS
M	HS	HS	HS	HS	HS
Pr	HS	HS	HS	HS	HS
Po				HS	
Interactions					
PS x M	N	N	N	S	N
R x M	N	HS	HS	N	N
PS x Pr	N	N	HS	HS	HS
R x Pr	HS	HS	HS	N	S
M x Pr	HS	N	S	HS	HS
PS x M x Pr	N	HS	HS	N	N
PS x R x Pr	N	HS	S	N	N
R x M x Pr	HS	S	N	N	N
Pr x M x R x PS	N	S	N	N	N
Po x PS				HS	
Po x R				HS	
Po x M				HS	
Po x Pr				HS	

* PS, particle size; R, resin content; M, moisture content; Pr, pressure; Po, position of SG coupon.
** HS, highly significant (at 1%); S, significant (at 5%); N, not significant.

ness of the finished moldings. Pressure had the greatest over all effect on molding properties of the variables studied.

Powdered synthetic resin adhesive mixed with wood particles had a highly significant effect on the properties of the moldings. Bending strength increased, water absorption decreased, specific gravity increased, and Rockwell Superficial Hardness increased as the amount of resin used increased. Resin content ranked second in influencing all properties of the moldings.

Moisture content of the wood particle and synthetic-resin adhesive mixture at the time of pressing in heated dies had a highly significant influence on properties of the moldings. Bending strength increased, water absorption decreased, specific gravity increased, and Rockwell Superficial Hardness increased with increasing moisture content. Moisture content came third in over-all influence on properties of moldings. Moisture content played an influential role in affecting the properties of moldings. In many instances, it would be economically desirable to vary moisture instead of resin to improve molding properties.

Size of wood particles used in this experiment had a highly significant effect on water absorption, specific gravity, and Rockwell Superficial Hardness. Water absorption decreased, specific gravity increased, and Rockwell Superficial Hardness increased as particle size decreased. Particle sizes used in the experiment had no effect on bending strength. Size had the least influence on molding properties of all the variables studied.

It has been demonstrated in this experiment that articles of compound curvature can be made with a wide variation in properties. Manipulation of variables to achieve given properties will depend upon economics and the feasibility of using a given combination of variables.

Literature Cited

1. Burkhart, R. L. 1948. Interior trim from wood works. Wood Products 53:44.
2. Cooke, W. H. 1953. Consolidated products from wood residues. Report No. L-2, Oregon Forest Products Lab.
3. Dickinson, T. A. 1953. Smart new tableware made from wood scraps. Wood and Wood Products 58:32.
4. Gottstein, J. W. 1950. Some studies of sawdust synthetic resin combinations for hardboard manufacture. Proceedings FPRS. IV:310.
5. Macdonald, M. D. 1950. Manufacture of consolidated products from wood residues. Proceedings FPRS. IV:289.
6. Midyette, A. L. 1957. Wood particle molding. Forest Prod. J. 7(1):1.
7. Miller, H. E. 1950. Preliminary report: wood-waste-and-resin products, their application and physical properties. Unpublished research paper of Miller Bros. Co., Venice, Calif. 5 p. (Mimeographed).
8. Sears, T. W. 1950. Variables affecting the properties of wood waste moldings. Northeastern Wood Utilization Council Bulletin 31:89.
9. Smith, R. R. 1948. Molding sawdust. Southern Lumberman 177;2224:40.
10. Turner, H. D. 1954. Effect of particle size and shape on strength and dimensional stability of resin-bonded wood particle panels. Journal FPRS. IV; 5:210.
11. Turner, H. D., and J. D. Kern. 1950. Relation of several formation variables to properties of phenolic resin bonded wood waste hardboards. U.S. Forest Prod. Lab. Report No. R 1786.
12. Williams, F. H., and J. Grano. 1954. The manufacture of molded articles from resin and bonded granulated wood. Journal FPRS. IV; 5:227.
13. Wood waste moldings find new markets. 1949. Modern Plastics 27:90.

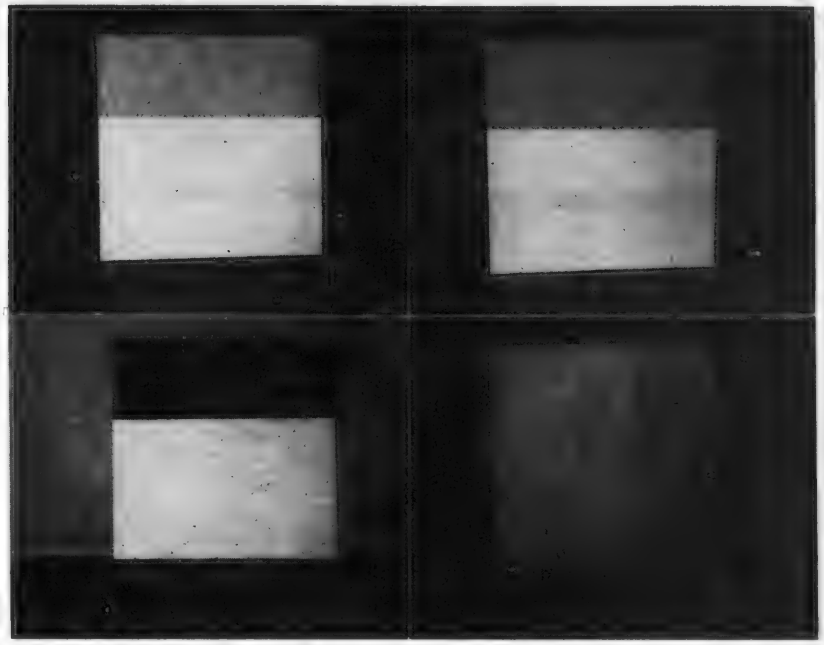
Elastomeric Adhesives...

THEIR USES IN FOREST PRODUCTS [1]

C. C. Booth, C. P. Hancock, and J. M. Hine

The Borden Chemical Co., Bainbridge, New York

These versatile adhesives are already used to bond wood products to metal and metal foil, plastic laminates, plastic and fabric overlays; paneling to walls; and for edge-bonding lumber and veneer.



Illustrations showing the use of contact cement, solvent and emulsified types, and casein-latex adhesives for bonding decorative plastic laminate to various substrates. Top left, laminate adhered to plywood; top right, decorative plastic laminate to particle board; lower left, decorative laminate to hardboard; lower right, two pieces of veneer spliced together by an emulsified contact cement.

The use of elastomeric adhesives has been known for over a century. In 1823, Charles Macintosh obtained a patent for bonding two fabrics together with a rubber solution to make a waterproof article.[2] Before World War II, reclaimed natural rubber was employed in air-drying types of adhesives, and during World War II, so-called synthetic rubber was utilized as a natural-rubber substitute.

The Authors: C. C. Booth holds BS and MS degrees from New York State College of Forestry. He is now head of the Wood Products and Abrasives-Foundry Section, Sales Development Lab.

C. P. Hancock, Technical Service Representative for over 25 years, is now a technical service specialist at the Sales Development Lab.

J. M. Hine has a BS in chemistry from College of Puget Sound, Tacoma, and did grad work at the U. of Oregon. He is now Development Manager, Western Operations.

The last decade has seen a tremendous increase in the use of synthetic elastomers, primarily because of the unusual properties they possess.[3]

The use of elastomeric adhesives in the forest products field is not new, although it must be considered an infant in comparison to older applications. Two decades ago, a 2-component adhesive system composed of a blended casein and a latex was being employed to bond metal to wood. Until the early 1950's, the number of elastomeric adhesives employed in the forest products industry was still very limited.

In the last five years, many elastomeric formulations have been found ideally suited for gluing tasks undreamed of prior to that period. This widespread usage is due in part to the creative ingenuity of the American manufacturer to produce new materials. A similar role has also been played by the adhesive supplier, whose foresightedness and research facilities have been equal to the demand for developing a variety of elastomeric compositions for specific bonding requirements.

The scene is constantly changing, and possibly between the preparation and delivery of this paper, an entirely new product based on an elastomeric adhesive may have come of age.

Definition of Elastomeric Adhesives

To appreciate the appeal of elastomeric adhesives for their many applications, it is well to have some concept of what they are. An elastomeric adhesive for forest products applications can be defined as a composition of an elastomer and a dispersing agent as the major constituents, with other chemical compounds frequently present to impart certain desired properties. The adhesive is capable of resisting stresses caused by contraction or expansion of

[1] Presented at Session IV, Glues and Gluing, FPRS 13th National Meeting, June 28-July 3, 1959, San Francisco.

[2] Wehmer, F. J. 1944. Synthetic rubber adhesives symposium on the application of synthetic rubbers. ASTM, p. 129.

[3] Cook, P. G. 1956. Latex—natural and synthetic. Reinhold Publishing Corp.

the components that result in deformation. This desirable physical property is particularly advantageous when laminates with different coefficients of expansion are combined. This is a rather broad description, but it does embrace the class of compounds generally utilized in the forest products field.

Types of Elastomeric Adhesives

There are numerous types of elastomeric adhesives commercially available today, but it is not within the scope of this paper to describe all of them. It is the intent of the authors to describe briefly typical products and their specific applications, with emphasis on advantages and disadvantages of the adhesive. A few of the more general types are as follows:

Casein-latex: An aqueous dispersion of casein and rubber-like compounds generally formulated to a non-volatile range of 30 to 40 percent. Creamy white in color, it can be bonded at room or elevated temperatures.

Contact Cement—Solvent Type: A highly compounded composition based on latex as the prime constituent, with hydrocarbons as the solvent or vehicle. It is generally formulated to contain 25 to 30 percent non-volatiles, but is available at lower non-volatiles content for spraying. Two types are commercially available: one contains flammable solvents and must be used in explosion-proof, well-ventilated areas; the other contains non-flammable solvents and requires only good ventilation of fumes.

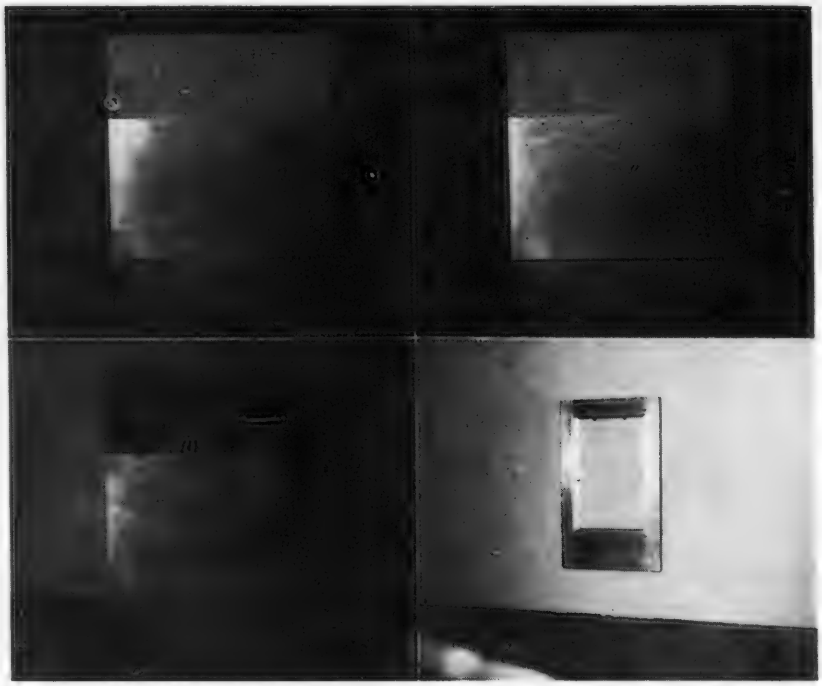
Emulsified Contact Cement: This formulation is similar to the solvent-type composition, except that the ingredients have been emulsified in water rather than the more costly and dangerous organic solvents. It is generally formulated to give approximately 50 percent non-volatiles, although formulations lower in solids are available for spray applications.

Rubber-Asphalt: The rubber latex is generally incorporated into an asphalt emulsion to give a product of from 45 to 75 percent non-volatiles. The dark color is sometimes objectionable and limits applications somewhat.

Typical Bonding Applications

To obtain a clearer picture of the various gluing jobs where elastomeric formulations are used, the applications are discussed individually with particular emphasis on the appropriate adhesive to employ.

Rigid Metal Bonded to Ligno-cellulosics: A rigid metal is defined as being 0.006 inch or greater in thickness. Metals thinner than this are considered to be foils.



Illustrations of the use of casein-latex and contact cements, solvent and emulsified types, to bond aluminum to various substrates. Top left, aluminum bonded to plywood; top right, aluminum bonded to particle board; lower left, aluminum bonded to hardboard; lower right, extruded aluminum bonded to a substrate to produce doors and windows.

Rigid metals glued to plywood represent one of the first, if not the first, utilization of an elastomeric adhesive where wood was represented as one of the components. A casein-latex solution was the initial adhesive employed, and still is considered the standard for this construction.

Recently, rigid metal has been commercially bonded to particle board, and there is every reason to believe that new outlets will develop for such a construction. Metal has also been bonded to hardboard for specialized applications, but this product has not found widespread use to date.

A casein-latex will set up at room temperature after a pressure period of several hours, or can be cured under heat and pressure within a few minutes. Adhesive spreads of 15 to 35 pounds per 1000 square feet of single glue line are usually adequate to provide a water-resistant bond. The bond can be upgraded with respect to water resistance by pre-priming the metal interface with a casein-latex adhesive and coating the plywood interface with a resorcinol adhesive. When the components are mated, the resultant construction forms a very durable glue line. Frequently, an inhibitor is incorporated into the casein-latex adhesive to minimize corrosion at the metal interface.

Contact cements, both solvent and emulsified types, have enjoyed some success in these applications, but do not offer the degree of water resistance that can be obtained with the casein-latex-resorcinol adhesive system. They do, however, require only contact pressure, which is usually obtained by nip rolls to combine construction components. Spreads of 160 square feet per gallon are usually adequate. Both surfaces to be bonded require at least one coat of cement, with two coats the usual practice for porous surfaces.

Recent development work with contact cements indicates that they can be hot pressed. This procedure requires the coating of only one of the surfaces to be mated, and thus reduces glue line costs substantially. One potential hazard is the unequal thermal expansion of the metal and ligno-cellulosic substrate.

Metal Foil Bonded to Ligno-cellulosics: The bonding of metal foil to a variety of subtrates has been steadily increasing the last several years. One of the largest outlets for adhesive has been the bonding of foil to hardboard. The operation is high speed in nature, and the adhesive sets very quickly under heat.

A casein-latex composition is being successfully employed since it offers low cost, good machinability, quick cure, and good water resistance. A formulation with a minimum of water is desired to reduce the hazard of water vapor at the foil-hardboard interfaces.

Another application for foil bonded to a ligno-cellulosic is illustrated by some manufacturers of tables and case goods. Here the foil is located between the face veneer and cross-band in a plywood construction, and serves as a heat conductor to protect the face surface from any hot object such as a cigarette.

The foil is generally supplied precoated with a casein-latex composition that facilitates its adherence to both the face and cross-band members by means of a urea-formaldehyde adhesive. The latter is usually the preferred mix for bonding the furniture-plywood construction.

An additional application is the bonding of foil to paper. Casein-latex adhesives predominate for this purpose because of the strength and flexibility afforded by the bond. Principal end uses are for insulation and packaging.

High Density Overlays Bonded to Ligno-cellulosics and Non-Ligno-cellulosics: The high-density decorative laminate bonded to plywood, particle board or hardboard best illustrates this category. Although urea-formaldehyde resins and polyvinyl acetate emulsions represent the major adhesives for this application, contact cements, both solvent and emulsified types, are used in substantial quantities. They afford easy application and require only contact pressure to fulfill the job. These advantages are extremely important to the layman or the small fabricator who does not have mechanical spreaders and pressing equipment.

In the case of a solvent-type contact cement, it is necessary to provide good ventilation to remove solvent fumes and to eliminate explosion hazards. An emulsified contact cement does not require such precautions. At least one coat of adhesive is required on each surface to be mated. Ample drying time should be allowed to insure a tack-free film, and thus assure adequate volatilization of solvent. This step is essential to obtain a good bond at the substrate interfaces.

Contact-type adhesives are also ideally suited for bonding overlays to rigid foam substrates as well as for laminating foamed articles. Foamed articles are usually composed of an agglomeration of closed cells, which minimizes the dissipation of the adhesive solvent. The surfaces that have been coated with contact adhesive are devoid of all volatiles before they are combined and pressed.

Other minor applications are the bonding of hardboard to wood, plywood, or particle board in some furniture components. Both contact cements and casein-latex compositions are employed for these applications.

Thin Flexible Sheets Bonded to Ligno-cellulosics: Recently there has been a trend toward the use of thin, flexible plastic and fabric overlays on plywood, hardboard, and particle board. There are several types of plastic-overlay materials being promoted, but the vinyl products appear to be the most numerous, primarily because of their versatility with regard to color patterns and appearance.

The term fabric as used here connotes sheet overlay material other than plastics. Examples are woven cane, textiles, leather, and canvas to name a few, all of which are found in commercial applications.

Contact cements, both solvent and emulsified types, are widely employed as adhesives a long with casein-latex and rubber-asphalt emulsion formulations. Each material, whether a plastic or fabric, seems to require some trial and error to determine the adhesive that is the most suitable.

Contact cements offer the advantage of requiring only contact pressure, but the hydrocarbon in the solvent causes deterioration of some plastics. Asphalt-rubber formulations offer fast set also, but their dark color is frequently objectionable. Casein-latex compositions are not always suitable because they require a prolonged pressure period that frequently cannot be tolerated.

Paneling Bonded to Rigid Substrates

Paneling materials are being promoted more and more for the home repairman as well as for the professional interior decorator. They include not only the decorative-faced plywood panels, but the newer flexible, reinforced, high-quality veneers.

As the use of paneling material in the home and office has increased, so has the need for a simplified adhesive system. Contact cements fulfill this need more than any other type of adhesive. They are easy to apply, and after a suitable drying period to permit the solvent to volatile, the panels can be installed quickly with only contact pressure.

Rubber-asphalt emulsions are also adaptable, but have not enjoyed the widespread success of the contact cements. This may be due in part to their somewhat lower rate of set as well as their objectionable dark color.

Edge Gluing Lumber and Veneers

The practice of edge gluing lumber and veneers, as well as edge banding panels, has long been dominated by the versatile urea-formaldehyde resins. The development of high-speed tapeless splicing and edge-banding equipment has made it increasingly difficult to formulate urea-resin mixtures that will give a fast enough cure and still maintain a suitable working life. A partial solution to this problem appears to be offered in the use of contact cements, both solvent and emulsion types. Laboratory tests have given strong indications that bonds of high strength may be obtained by hot pressing these materials in standard heat setting machines. The adhesive need only be applied to one surface in this case, dried to permit solvent escape, and processed in the regular manner. Good bonds have been obtained up to three days after the adhesive was applied.

This procedure has taken a slightly different direction in the fir plywood mills on the Pacific Coast, where even the heat has been eliminated. The adhesive in this case is applied to both surfaces of the edge joints at the jointer, allowed to dry briefly, and is then merely run through the crowding sections of various heated and electronic edge-gluing machines without heat. Several machines have been, or are being, built especially for this purpose, and should be more economical since they will not contain heating elements. The emulsion type of contact cement is used almost exclusively in this field.

Miscellaneous Applications

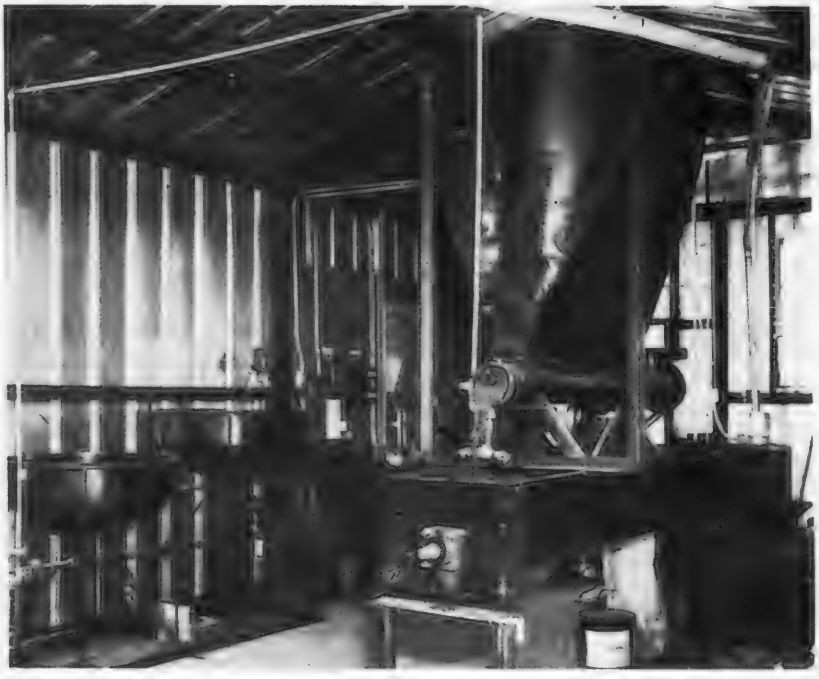
No mention has been made of unmodified latex compositions, either natural or synthetic, since they find no usage in the wood industry to the author's knowledge. They do possess many interesting properties, however, and it is conceivable that eventually some utilization will be found that will benefit the forest products industries.

Another group of adhesives that has been intentionally overlooked is the polyvinyl acetate, polyacrylate, polystyrene, and polyvinyl chloride polymers. There is a belief in some quarters that such products are elastomerics, but definition and literature fails to support this claim. It is true that many of these adhesives possess certain physical properties similar to elastomeric formulations, and a few are used in a analogous manner, but they are not actually elastomeric compositions.

Conclusions

It is evident that elastomeric adhesives are firmly established in the forest products field. There are several types of formulations commercially available that are providing good performance in a variety of applications. They are a versatile adhesive group that offers many unusual advantages. As the forest products field continues to expand, there is every reason to believe that elastomeric adhesives will find more widespread applications.

PROCESS FOR CONVERTING



Fersolin pilot plant—Sawdust feeds into mixing trough where it is sprayed with acid.

E. FARBER
Retired, formerly TECO,
Washington, D. C.

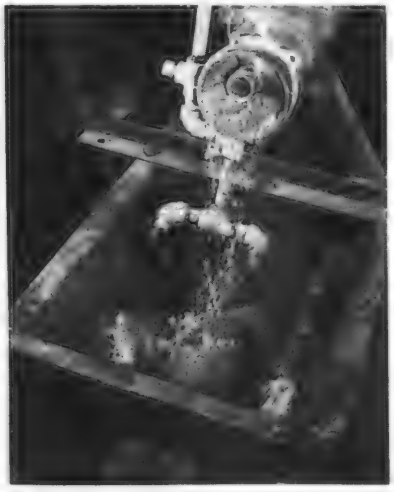
R. R. HIND
Pope & Talbot and Fersolin Corp.,
San Francisco, Calif.

Fine sawmill residues are treated with mineral acid, fortified with plant nutrients, heated, and conditioned. The product is an efficient fertilizer carrier and physical soil conditioner.

THE ENDEAVOR TO UNDERSTAND the relationship between soils and crops has gone through many phases. For a time, the emphasis was placed on organic humus. When it was demonstrated that humus failed to supply all the substances necessary for plant growth, attention was shifted to mineral substances, and more to quantity than the biological availability. Recently, the physical structure of the soil has claimed important attention.

Gradually, an equilibrium of understanding is being approached that recognizes the interplay of many factors on which the productivity of a soil depends. An attempt was made to keep this entire complex in mind in the development of a combined soil conditioner—fertilizer carrier from chemically modified wood.

Sawdust and acid feeding into mixing trough.



Survey of Literature

Attempts and proposals to use wood chips or sawdust in soils have been made for a long time; much, of unequal value, has been published about such use. Only a selection from the more recent literature will be surveyed here.

When wood chips, bark, or straw are applied as mulches on the surface of the soil, intake of water was increased, and run-off and erosion were reduced. Duley and Kelly (3) reported measurements of such favorable results.

With mulch tillage, the problem of nitrogen deficiency begins to arise. Schaller and Evans pointed this out (10), and recommended additions of fertilizers.

When sawdust is incorporated in the soil, the nitrogen content should be raised by adding 180 pounds of ammonium sulfate, or its equivalent, per ton of sawdust (12).

Roberts and Stephenson (9) found that "where 3 to 4 inches of fir sawdust have been incorporated in the soil, it has been approximately four years before decomposition of the sawdust has progressed to the stage where there is no longer any depression of nitrates." For tomatoes and potatoes, they estimated the need per acre of added, actual nitrogen in the fertilizer as 400 pounds in the first year, 200 pounds in the second, and less in the third.

"The use of sawdust for mulches and soil improvement" was surveyed by Allison and Anderson in 1951, with 30 literature references (1). They conclude that the required compensating nitrogen should be applied "in at least two, and preferably more, applications during the season."

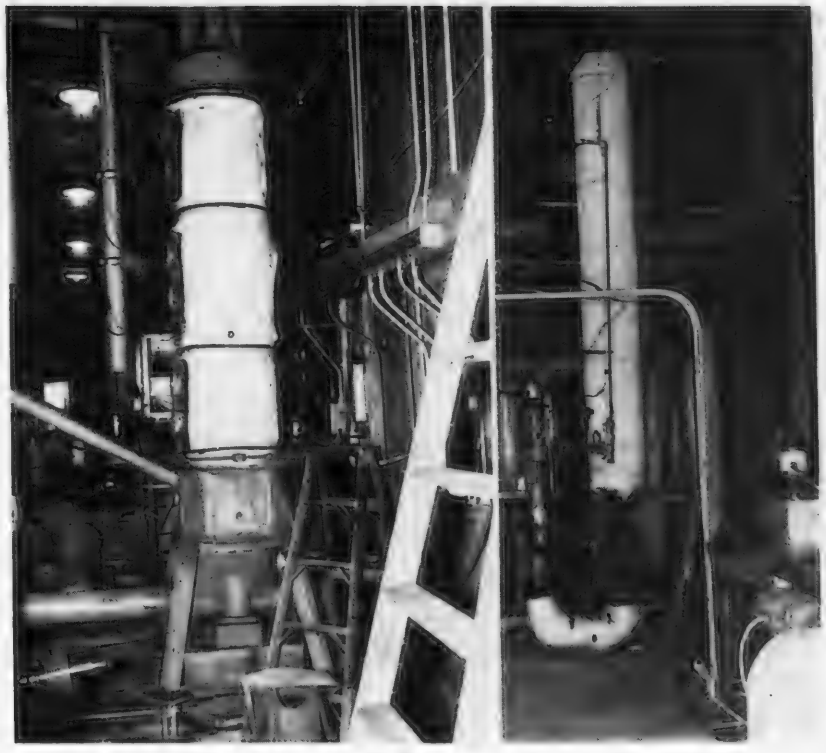
The possibility of preliminary digestions of the wood by fermentation was discussed by Stranks (11). "Composting" of sawdust (which itself has a long history) was studied in several laboratories. Wilde recently reported results obtained with *Caprinus ephemerus* as the cellulolytic micro-organism (16).

Efforts like these are aimed at avoiding the adverse effects of untreated sawdust, while retaining the beneficial ones in soil structure and the complicated processes that govern the accessibility of nutrients to the plant roots (8, 13). High solubility of nutrients in water is not always the decisive factor; it is often better to provide them in a form in which they become gen-

The Authors: Eduard Farber received his PhD in organic chemistry from Leipzig Univ. He was associated with several European universities and chemical firms, and served as chief chemist for TECO from 1943 to 1958.

Robert Hind holds a BS in industrial engineering from Stanford. He is Secretary of Pope & Talbot, and Vice-President and General Manager of Fersolin Corp.

Sawdust into Fertilizer[1]



Ammoniator, left, and reactor, right, of Fersolin pilot plant.

erally available during the period of plant growth. Nutrients and trace elements have successfully been applied in an "insoluble" form, embedded in a glass matrix (8).

A Process for the Chemical Condensation of Wood

The development of a chemical method for improving wood for use in soils began with the following knowledge:

1. The primary cause of nitrogen-depletion is the availability to soil micro-organisms of the carbohydrate fraction of the wood. The micro-organisms consume nitrogen while breaking down these carbohydrates, and thereby deprive plants of an essential food element. Lignin is relatively resistant to decomposition, so the higher the proportion of lignin, the lower the availability of the carbohydrates as micro-organismic food and the lower the nitrogen draft. This was shown in long series of tests by Virtanen (15) and others.

2. While acids are hydrolyzing agents for cellulose under certain conditions in the presence of water, they can act as condensing agents under other conditions in the practical absence of water (6). Monomeric glucose can thus be converted into polysaccharides by small amounts of acids in the absence of water (4). The question was whether a highly polymeric carbohydrate like cellulose could be further "condensed" through a reaction catalyzed by small amounts of acids and anhydrous conditions.

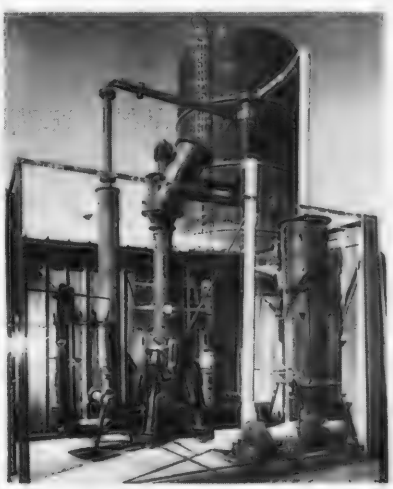
It was shown that such a reaction—or series of chemical changes—occurs quickly when wood is heated in the presence of mineral acids, without the application of pressure and at temperatures well below the charring point. Although the reaction involves more than only the removal of free and molecular water, the solid product of this condensation is obtained in high yields. It contains carbohydrates in much lower proportions than in the original wood. Lignin-like materials and other non-carbohydrate materials are found in such increased proportions that they must have their origin in the condensation of the carbohydrates (5).

The product thus obtained, after appropriate conditioning and neutralization (7), proved to be beneficial to soils and plant growth without the adverse effects on nutrient availability. The product was given the name "Fersolin", a contraction of fertility, soil and lignin.

Technical Development of the Process

Technically, the process requires three steps: addition of the acid with uniform distribution in the sawdust, heating to reaction temperature at atmospheric pressure, and conditioning and neutralization of product. Although these are simple steps, the control problems are complex.

The control problem is particularly complex in the heating step. Heat transfer to sawdust through solid surfaces is slow when the temperature gradients are small, and when they are high, burning may be difficult to avoid. Direct heating through contact with hot gases can be sufficiently rapid, but it must be accompanied by control of time, temperature, and exposure to the atmosphere to prevent com-



Fersolin pilot plant.

[1] Presented at the General Session, Session CVIII, FPRS 13th National Meeting, June 28-July 3, 1959, San Francisco.

[2] Numbers in parentheses refer to the Literature Cited at the end of this report.

Fersolin pilot plant at right. To left is commercial plant under construction at Santa Rosa, Calif.

bustion. Even after it is cooled an unconditioned product of this reaction may undergo "spontaneous" combustion.

A series of large-scale production runs in standard commercial dryers and furnaces were undertaken in 1952 and 1953. Although some control difficulties were encountered, a quantity of satisfactory product was manufactured.

On the strength of these tests, a pilot plant was constructed at Oakridge, Oregon, in 1953–54. This plant consisted of a rotary kiln dryer, about 4 feet in diameter and 16 feet long, in which the acidulated sawdust was heated while exposed to a flow of hot combustion gases, together with the necessary conveying and mixing equipment. Production of this plant reached rates of over one ton per hour, and demonstrated the feasibility of continuous production. Several hundred tons of Fersolin were manufactured for the first large-scale field tests. The equipment could not be controlled adequately, however. Considerable variation in the final product was encountered, and fires were a common problem. Consequently this plant was closed down in December 1954, and subsequently dismantled.

The next phase in process development consisted of construction, in January 1955, of a small-scale pilot plant based on a new principle. This plant consisted primarily of a sawdust dryer and an electrically heated, inclined vibrating table over which the dry acidified sawdust was passed. Although satisfactory Fersolin was produced, there was still considerable variability. Further, the equipment was too costly and cumbersome for scaling up to commercial production.

In one series of runs, the acidified sawdust was recycled repeatedly through the flash dryer until satisfactory conversion was accomplished. This discovery led to development of a vertical reactor, which is the basis of the present production plant[3].

[3] Patent application pending.

In the present method, the acidulated sawdust is introduced continuously into a hot stream of combustion gases that moves upward through a tube and into an enlarged cylindrical section or "reacting zone."

Product residence time in the reaction zone can be controlled by simply varying gas velocity. Thus, drying plus the desired degree of reaction are obtained in a single pass with gas temperatures of 1200° to 2000° F. at the inlet. A uniform product is obtained in spite of wide variation of sawdust particle size. The residence time of the solids in the reactor at the controlled velocity is related to the cross-sectional area of the particles. The smaller particles are held in the hot gas stream for a shorter time than the larger particles. When sawdust with a range of particle sizes is sprayed with acid, the smaller particles, which have more surface area per unit of weight, absorb a greater proportion of acid. They are thus more reactive when heated and are normally subjected to a greater degree of chemical conversion than are the larger particles if subjected to heat for the same length of time. Since these small, reactive particles are held in the reaction zone for a shorter time than are the larger particles, however, this condition is minimized and the degree of chemical conversion obtained with both the small and large particles is essentially the same; thus producing the desired uniform product. Moreover, none of the particles remain in the hot gases long enough to be heated to ignition temperature, and losses due to the burning of fines are virtually eliminated.

When they leave the reaction zone, the gases and solids are separated in a cyclone. The waste gases are incinerated to destroy noxious fumes and are exhausted to the atmosphere. The possible recovery of useful by-products from the discharge gases is a subject for further exploration. Heat produced in fume incineration may be used for drying or elsewhere in the plant.

The material manufactured in the process thus far outlined met the initial objective of a stable soil conditioner. The process proved to be adaptable to all wood species used as well as to a number of similar organic wastes such as sugar-cane bagasse, rice hulls, cotton stalks, and coffee grounds. Large-scale field tests and laboratory experiments verified its efficacy in improving physical soil properties.

Certain economic shortcomings were apparent, however. Applications of 10 tons per acre and more proved necessary. Even at minimum production and freight costs, the price per acre of such large applications would be prohibitive for general agricultural use. The loss of the agricultural market would reduce demand to a few specialized uses, and would preclude the large-volume consumption of sawmill wastes, which was the original objective.

A probable solution to this economic problem lay in the incorporation of plant nutrients in the soil conditioner. The converted product was highly absorbent, and should make an efficient plant-food carrier. Further, after the nutrients are consumed, the very stable conditioner-carrier would remain in the soil and build up with successive applications. In the long run, the user would get efficient fertilizing plus improved physical structure from the organic residue.

Production experiments were begun in 1954, and results even exceeded expectations. Phosphorus was supplied by using phosphoric acid as a portion of the catalyzing mineral acids. This resulted not only in satisfactory incorporation of this primary plant-food element, but the mixed acids proved to be more efficient in catalyzing the conversion reaction than a single mineral acid.[4]

Addition of nitrogen in the form of ammonia was selected because it would provide the required neutralization of the acidic product, and thereby eliminate the need for lime or some similar material as a neutralizer. Either aqueous or anhydrous ammonia proved satisfactory.

It was observed, however, that when anhydrous ammonia was introduced to the hot product, a portion of the nitrogen in the finished product appeared in the form of relatively insoluble organic compounds that are only slowly available to plants. The inorganic nitrogen apparently was present both adsorbed on particle surfaces and absorbed into the interstices of the individual particles. The net result was that the product supplied a source of quickly available inorganic

[4] Patent application pending.

nitrogen and a reservoir of more slowly available organic nitrogen released gradually during the growing period.

This led to experimentation with a variety of devices in which to conduct the ammoniation phase. Control of temperature and residence time proved important in regulating the proportion of organic nitrogen formed.

The final plant design employs a countercurrent vertical ammoniation tower in which the solid material is confined for several minutes while anhydrous ammonia is introduced and allowed to drift up through the bed. The solid acidic product from the reactor is introduced continuously at the top of the tower and removed continuously from the bottom by a screw feeder. Flow rates are controlled so that all ammonia is absorbed below the top of the product bed.

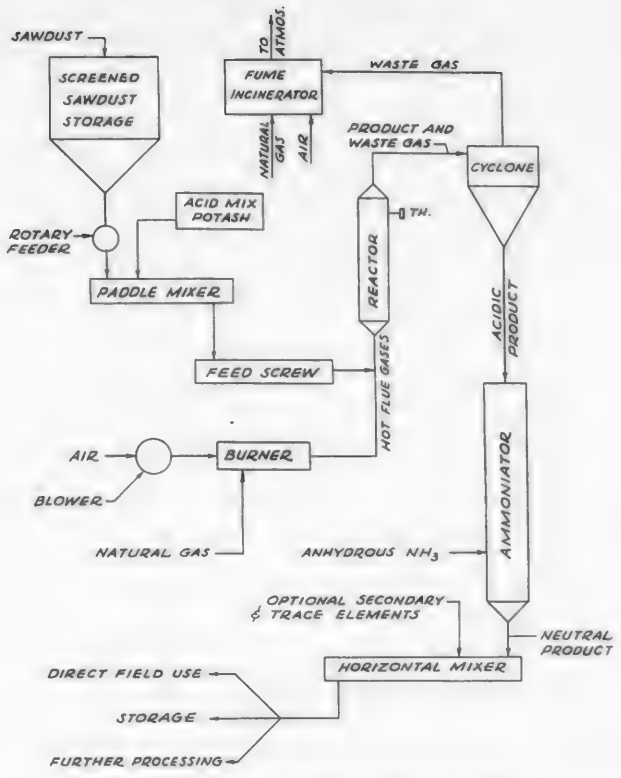
No difficulty was encountered in adding potash to complete the supply of primary nutrients, or in adding minor amounts of so-called trace elements where warranted. Following is a typical analysis of the product made from Douglas-fir sawdust before addition of any trace elements:

Organic nitrogen	2.16%
Ammonic nitrogen	4.02%
Total nitrogen	6.18%
Total P_2O_5	2.60%
K_2O (Water soluble)	3.86%
Sulfur	6.21%
Moisture	2.47%
Zinc	10.5 ppm
Copper	3.1 ppm
Manganese	26.5 ppm
Iron	14.4 ppm
Boron	5.3 ppm
Molybdenum	0.25ppm
Calcium	2.83ppm
Magnesium	6.4 ppm
pH	6.0

Product Testing

The earliest growth testing of the carrier-conditioner was related to the original concept of its function: as a mechanical soil conditioner. Early trials were made by the TECO laboratory, government agencies, and other cooperators. These tests were on a greenhouse scale, and results generally indicated earlier and better germination and improved growth in pots treated with the conditioner.

The scope and scale of testing has been vastly increased in more recent years. These trials were designed to evaluate the fortified conditioner as a complete fertilizer. Field-scale tests under supervision of a private laboratory compared the fortified conditioner with standard commercial fertilizing methods on lettuce, corn, potatoes, celery, carrots, strawberries, and other row crops. In all, over 75 acres of carefully replicated tests were conducted, and significantly improved yields were observed in nearly every case.



Flow chart showing complete processing system.

Perhaps the most impressive growth testing was conducted and reported by the University of California (14). These tests compared Fersolin with leading long-lasting fertilizers now on the market on a variety of flowering plants and turfgrasses. The report concludes that the fortified conditioner compares favorably with the best of the other mtaerials in providing a quick, yet safe, supply of initial plant food and good long-lasting characteristics.

Other tests have been concerned with the carrier material itself. One state university investigator concluded that the reacted material is "significantly more resistant" to decomposition than raw wood, and should resist decomposition in the soil for at least five years (2). Investigations by the Stanford Research Institute, based on spectrosopic and chemical methods, confirm that the cellulose content of raw wood is decreased while lignin and lignin-like materials are increased by the conversion process.

Economics and Marketing

Preliminary cost studies show that a complete fertilizer-conditioner, containing about 4 percent nitrogen and 3 percent of phosphoric acid and potash, can be profitably sold to volume users at about $45 per ton bulk, f.o.b. plant. This figure is based on a full-scale production plant with output of about 50 tons per 24-hour day. Cost of special preparation and packaging for retail markets and specialized uses will, of course, sharply increase selling prices above this level.

Extensive surveys of agricultural and retail users indicate a satisfactory market potential for the product at profitable price ranges. Agricultural use will be confined to high-value crops such as vegetables, fruits and ornamental plants. It has a particular appeal where physical soil problems exist, since successive applications leave an increasing amount of organic residual to open up heavy soils or improve water retention in sandy soils.

Fersolin's long lasting character and its safety from nitrogen burn make it suitable for home garden use. The material may be compressed into pellets or sheets and subsequently granulated to reduce its bulkiness and to increase its attractiveness to home gardeners.

Since both the major raw material and the finished product are bulky, it is best to locate production facilities close to markets. Optimum plant size also favors a number of small plants over a few large plants. Ideally, each production plant should be scaled to serve markets within a radius of about 100 miles, and should be located adjacent to a raw material source and have access to a cheap fuel supply, prefer-

ably natural gas. The widespread nature of the basic lumber industry and the existence of remanufacturing plants near metropolitan centers makes this arrangement possible in nearly all U.S. market areas, as well as in much of the rest of the world. In foreign areas where lumber wastes are not plentiful, such woody agricultural by-products as sugar-cane bagasse may be used in the process.

Conclusions

An economical method has been found for conversion of fine sawmill wastes into a useful agricultural product. The process consists of treatment with mineral acids, addition of plant nutrients, heating, and conditioning. The process has been adapted to continuous flow production. The finished product serves as an efficient fertilizer-carrier and a physical soil conditioner.

Extensive field research has demonstrated the value of the carrier-conditioner, particularly in high-value crops and where physical soil problems exist. The process has been through the pilot production phase, and a full-scale commercial plant is to be in operation by the end of 1959.

Literature Cited

1. Allison, F. E., and M. S. Anderson. 1951. U.S. Dept. of Agric. Circular No. 891.
2. Bollen, W. B., and K. C. Lu. 1956. Chemical and microbial evolution of the decomposability and nitrogen availability of reacted sawdust, bagasse, and coffee grounds. Oregon Agric. Expt. Station.
3. Duley, F. L., and L. L. Kelly. 1941. U.S. Dept. of Agric. Circular No. 608.
4. Farber, E. 1936. U.S. Patent No. 2,027,904.
5. Farber, E. 1951. U.S. Patent No. 2,574,027.
6. Farber, E. 1952. Tappi, Jan., p. 112A.
7. Farber, E. 1956. U.S. Patent No. 2,735,756.
8. Nikiforoff, C. C. 1959. Science, 129: 186.
9. Roberts, A. N., and R. E. Stephenson. 1948. 40th Annual Rep., Oregon State Horticultural Soc.
10. Schaller, F. W., and D. D. Evans. 1954. Agric. Eng. 35(10):731.
11. Stranks, D. W. 1952. Pulp and Paper Mag. of Canada, Convention Issue.
12. Turk, L. M. 1943. Mich. Agric. Expt. Sta. Quarterly Bul. 26:10.
13. U.S. Dept. of Agric. 1957. Yearbook of Agriculture, chap. of Soils.
14. Univ. of California. 1958. Studies of several long-lasting nitrogen sources on several floral and nursery corps and turfgrasses. March.
15. Virtanen, A. I. 1946. Nature, 158: 795. *See also* W. B. Bollen and K. C. Lu. 1957. Soil Science Soc. of Amer. Prod. 21: 35.
16. Wilde, S. A. 1958. Forest Prod. J. 8(11):323.

A NEW PERFORMANCE TEST FOR INTERIOR PLYWOOD AND ITS APPLICATION TO PANELS CONTAINING White-Pocket Veneer[1]

R. H. Ripley
Douglas Fir Plywood Association,
Tacoma, Washington

Cyclic soaking, controlled drying, and critical examination of test specimens are combined to make an effective quality control tool for evaluating plywood panels made with white-pocket veneer.

THE INCREASING USE of Interior-type Douglas-fir plywood in structural applications, primarily as sheathing, over the past several years has resulted in its exposure to conditions, such as unprotected storage and long exposure to weather during construction, ordinarily not considered normal for Interior-type panels. The glueline quality attained with the glues and manufacturing techniques formerly proven satisfactory has shown increasing evidence of inability to meet the new demands, and it has become apparent that, in order to hold markets and increase sales in the construction field, a more adequately bonded class of panels was required. The obvious first step was to develop a test specification that would assure the glueline quality required.

The proposed use of white-pocket-infected Douglas-fir veneer in standard grades of Interior-type panels posed a glueability question. Tests had shown this class of plywood to exhibit certain inconsistent reactions when tested by procedures described in CS45–55, the Commercial Standard for Douglas-fir plywood. Bonds attained with non-durable glues sometimes gave the appearance of satisfactorily quality and required thorough examination and analysis to detect inherent weaknesses. To detect these weaknesses adequately a more discriminating test was indicated.

It was recognized that the principal weakness of the existing Interior-type test lay in the lack of control during the drying portion of test cycles. This resulted in poor drying of test specimens and inadequate stressing of glue joints, and thus failed to detect a high proportion of the poorly bonded panels. A second major fault was the lack of reproducibility inherent in the test procedures.

The problem, then, was to establish procedures that would provide good wetting, good drying, and reproducibility. It was also important that the test be realistic in terms of conditions to which plywood might be exposed in service.

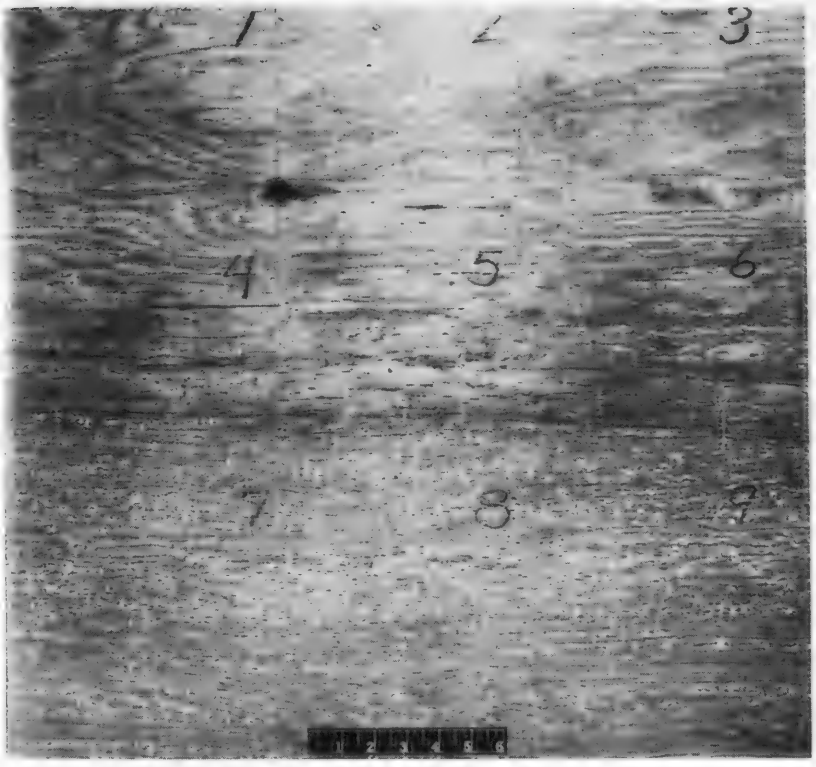
The following is an account of the development of new test procedures in three phases. These phases are 1) selection of a new specimen size, 2) application of new test procedures to interior plywood containing white pocket, and 3) effectiveness of new test procedures in detecting poor bonds.

Selection of a New Specimen Size

Procedure: Testing as discussed here, since it is dependent upon good alternate wetting and drying of test specimens requires a specimen size and cyclic exposure capable of producing

[1] Presented at Session II, Veneer and Plywood, FPRS 13th National Meeting, June 28-July 3, 1959, San Francisco.

The Author: Robert Ripley, a plywood technician since 1938, is in charge of all quality maintenance testing operations for DFPA's two laboratories.



Plywood panel showing typical white pocket infestation.

true cyclic conditions. The CS45-inch-square test specimen failed to meet these requirements, primarily because of the difficulty of drying the relatively large mass of wood adequately. Some smaller specimen size was therefore required to attain desired results.

Laboratory work that lead to the development of new test procedures included an experiment to determine the extent of moisture-content changes during cyclic testing for four specimen sizes and three drying conditions. Specimens in 1 by 6, 2 by 6, 3 by 6, and 6 by 6 inch dimensions were tested cyclicly by a four-hour soaking period in cold tap water (65°F.) followed by three different drying periods consisting of 19 hours at room temperature (70°F.), 19 hours at 100°F., and 19 hours at 130°F. The 70°F. drying was carried out under normal room atmospheric conditions, and drying at the two elevated temperatures was accomplished in a laboratory drying oven with forced-air circulation.

Specimens tested were prepared from laboratory glued panels of ⅜-inch, 3 ply, and ¾-inch, 5 ply constructions made by the cold-press process. All veneer was of Douglas-fir heartwood selected for freedom from defects and for uniform quality. Ten specimens were tested for each of the 12 test conditions. Moisture-content values at the end of the wet and dry sections in each cycle were recorded as averages for each group of 10 specimens for each condition tested and are noted in Table 1: Values are composites of figures obtained over four test cycles.

Results: Data in Table 1 show that changes in moisture contents of all specimen sizes tested in the soak—air-dry cycle were insufficient to produce shrinkage or swelling stresses of any appreciable degree. Moisture-content changes in the two cycles with high-temperature drying were sufficient to produce severe stresses in all specimen size classes, with the drying efficiency in proportion to specimen size.

From the standpoint of efficiency alone, the 1 by 6 inch specimen was indicated as the best test tool, with the 2 by 6 and 3 by 6 inch specimens next. Both performed at about the same level. The 6 by 6 inch specimen was considered inefficient because of the relatively poor drying attained.

In selecting a satisfactory specimen size, factors other than drying efficiency alone required consideration. A test specimen, to be used as a quality control tool, must be easily handled in large quantities, easily marked with identifying numbers, and readily cut from sample panels. After consideration of factors involved, it was felt that the 2 by 6 inch specimen best fulfilled all of the requirements.

Application of New Test Procedures To Interior Plywood Containing White Pocket

In March, 1958, a study was initiated at the DFPA Quality Control Laboratory to investigate the gluing characteristics of white-pocket-infected Douglas-fir veneer in Interior-type panels. This project was undertaken because of the intense interest by plywood manufacturers in the utilization of this class of veneer, and the absence of complete information on its gluing characteristics.

Procedure: The work was organized to test five typical Interior-type glues and three veneer classes. Three cyclic delamination tests and two specimen sizes were used following the 4-hour soak, 19-hour drying times previously described.

Douglas-fir heartwood veneer in ⅛-inch thickness and three classes was obtained from a single source. This material was graded so that the three classes were each of uniform quality. Classes were: "Sound" (defect free), "Light" (white-pocket advanced beyond incipient or stain stage to point where pockets are present and plainly visible, mostly small and filled with white cellulose; generally distributed with no heavy concentrations; pockets for the most part separate and distinct; few to no holes through the veneer), "Heavy" (white-pocket containing a great number of pockets, in dense concentrations, running together and at times appearing continuous; holes may extend through the veneer but wood between pockets appears firm). Sufficient veneer was cut and conditioned to 2-½ to 3 percent moisture content to manufacture 90 five-ply panels 12 by 24 inches for each of the 5 glues included in the experiment. Thirty panels for each glue were made with all "Sound" stock to serve as controls; 30 were made with "Light" stock inner plies and "Sound" outer plies, and 30 were made with "Heavy" inner plies and "Sound" outer plies to test per-

Table 1.—MOISTURE CONTENT VALUES FOR FOUR SPECIMEN SIZES AND THREE CYCLIC TEST CONDITIONS. VALUES ARE AVERAGES FOR 10 SPECIMENS PER CONDITION

Specimen Size	Test Cycles					
	4-Hour Soak	Air-Dry 19 Hours	4-Hour Soak	Drying at 100°F. 19 Hours	4-Hour Soak	Drying at 130°F. 19 Hours
Inches	%	%	%	%	%	%
1 x 6	40	22	43	8	44	4
2 x 6	37	22	39	11	40	5
3 x 6	36	22	35	12	38	6
6 x 6	33	21	33	15	38	9

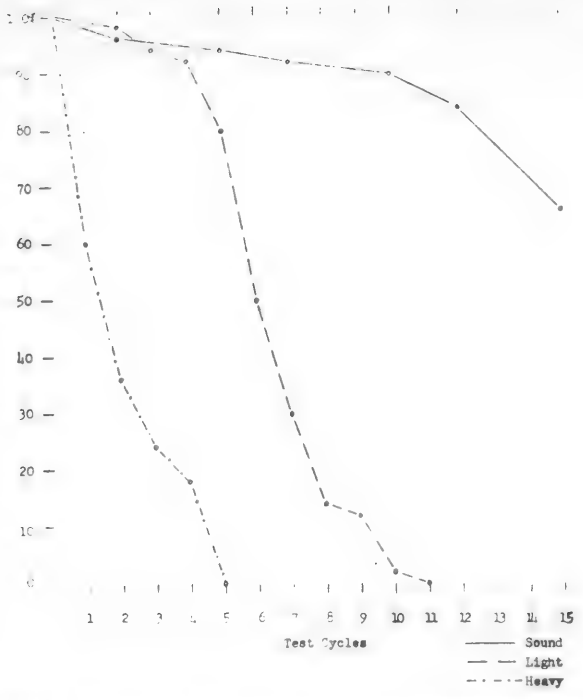


Fig. 1.—Cold-press soy glue, dried at room temperature. Performance of 50 2-by-5-inch specimens for 3 veneer grades, plotted as percent that remained sound for each cycle.

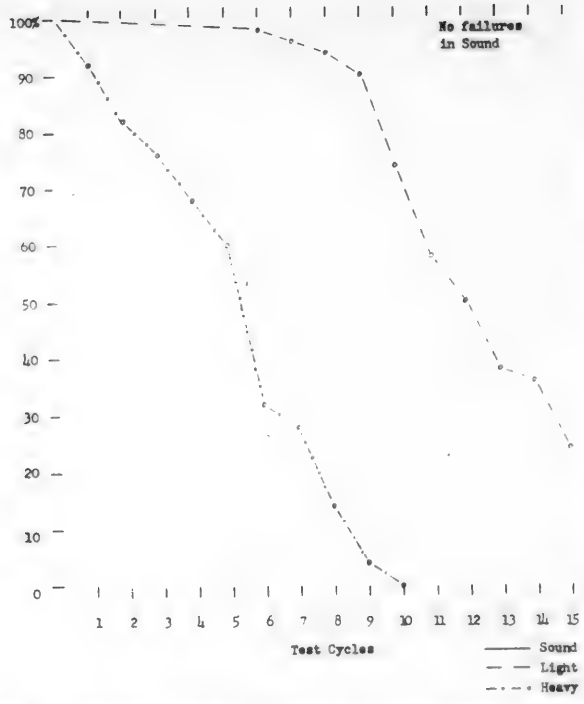


Fig. 2.—Cold-press blood glue, died at room temperature. Performance and specimens as indicated in Fig. 1.

formance of the various glues with the 3 veneer classes.

Representative glues of the following types were used: cold-press soybean, cold-press blood, hot-press protein, hot-press blood-resin and hot-press phenolic resin.

Panels were glued with laboratory equipment and in accordance with the glue manufacturer's recommendations for adhesive use. Glue spreads and assembly times were optimum.

Fifty test specimens in each of two sizes, 2 by 5 inches, and 5 by 5 inches were prepared for each variable under test. Variables included 3 cyclic conditions each with a 4-hour soak at 65°F. followed by 19 hours of drying at room temperature, 100°F., and 130°F., veneer classes, and 5 glues. Thus, 45 variables were tested with 50 specimens of each size, which made a total of 4500 specimens.

Tests were carried out over 15 cycles for all of the cyclic test conditions. Specimens were examined at the end of each drying cycle, and any specimen that showed total continuous delamination of ¼ inch or more in depth and over 2 inches in length along the edges was considered to have failed.

Results: Table 2 records test data in terms of percentage of specimens that passed three cycles for each condition tested. With 85 percent of the specimens passing as the minimum performance requirement, data show that resin and hotpress protein fortified with resin are the only adhesive types tested capable of attaining good gluebond quality with all veneer classes. The three remaining glues all showed good performance with "Sound" veneer under all test conditions. Cold-press blood and hot-press protein bonded "Light" white-pocket satisfactorily, but failed with "Heavy" white pocket in the controlled-temperature cyclic tests. Hot-press protein performed at a higher level than did cold-press blood, but still failed. Cold-press soy bean glue failed with both "Light" and "Heavy" white-pocket in the controlled-temperature cyclic drying tests. It showed satisfactory performance with "Sound" veneer only.

The effectiveness of the controlled-temperature cyclic drying test in detecting inadequate bonds in comparison with that of the room-temperature cycle is obvious when performance data are compared. Figures do not indicate any substantial differences between the 100°F. and 130°F. drying cycles.

Figs. 1, 2 and 3 record test data for three glues (resin and hot-press protein fortified with resin not charted since no failures developed) in room-temperature cyclic drying testing; Figs. 4, 5, 6 and 7 record data for the 100°F cycle and Figs. 8, 9, 10 and 11 record data for the 130°F. drying cycle. Resin performance was not charted since no failures developed. Only data for the 2 by 5 inch test specimens are charted. The 5 by 5 inch specimens showed results parallel with those for the 2 by 5 inch specimens but at a lower sensitivity level; that is, the specimens did not show as high a rate of failure.

The charted data show wide differences in the glueline quality realized with the three veneer classes, "Sound" panels rated best, "Light" panels rated lower, and "Heavy" panels at the bottom.

As this work is predicated upon Laboratory-glued panels with gluing conditions under strict control so as to eliminate variables other than veneer classes and glue types, it is reasonable

Table 2.—EFFECTIVENESS[1] OF NEW TEST PROCEDURES ON PANELS CONTAINING WHITE POCKET VENEER

Glue Type	Room Temperature			100°F. Drying			130°F. Drying		
	Sound	Light	Heavy	Sound	Light	Heavy	Sound	Light	Heavy
	%	%	%	%	%	%	%	%	%
Soy CP	96	94	24	98	42	6	98	30	4
Blood CP	100	100	76	100	100	20	100	90	20
Protein HP	100	100	92	100	98	58	100	100	68
Protein and Resin	100	100	100	100	96	96	100	100	96
Resin	100	100	100	100	100	100	100	100	100

[1]Performance of 5 glues and 3 cyclic tests are recorded for 3 veneer grades as percentage of test specimen that passed 3 test cycles.

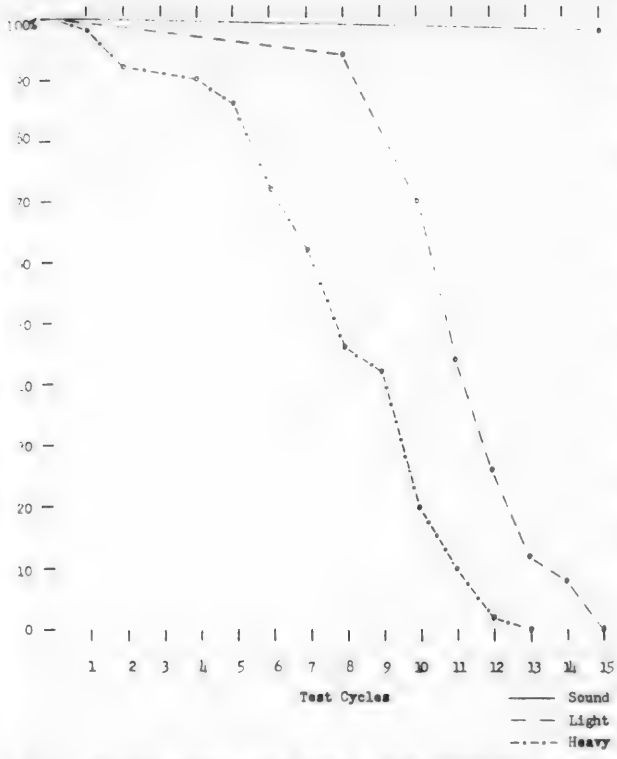


Fig. 3.—Hot-press protein glue, dried at room temperature. Performance and specimens as indicated in Fig. 1.

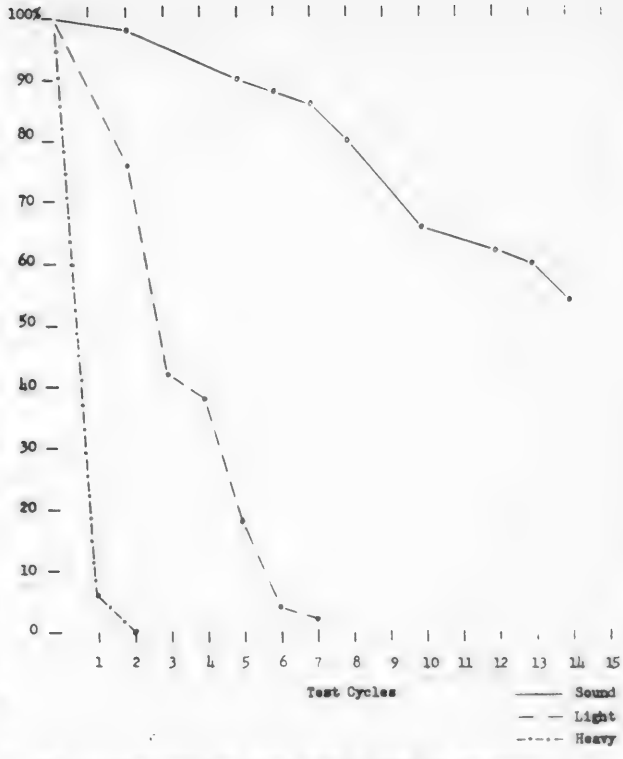


Fig. 4.—Cold-press soy glue, dried at 100° F. Performance and specimens as indicated in Fig. 1.

to assume that the performances of the various glues and veneer classes are maximum and do not necessarily indicate that these same performance levels would be realized on mill-manufactured panels. It is probable that mill-glued panels made with the same veneer classes would perform at a somewhat lower level because of the unavoidable variables that appear during mill gluing processes.

Effectiveness of New Test Procedures in Detecting Poor Bonds

Parallel with the work on gluing white-pocket-infected veneer, a laboratory gluing study was initiated to evaluate the effectiveness of the new test specimen and a cyclic test based on 100°F. drying for detecting gluing defects caused by poor gluing conditions.

Test panels of 7/16 inch, 3-ply construction were glued in the laboratory press with a standard hot-press adhesive. All panels were of Douglas-fir heartwood and were pressed at 240°F. for 5 minutes at 175 psi 2 panels per press opening.

Six gluing conditions were observed:

1. In accordance with good gluing practices and following recommendations of the glue supplier. These panels were used as controls.
2. Assembly time 25 percent longer than maximum recommended as safe. (20 minute TA)
3. Assembly time 88 percent longer than maximum recommended as safe. (30 minute TA)
4. Glue spreads 12 percent lower than minimum recommended as safe (75 pounds).
5. Glue spreads 24 percent lower than minimum recommended as safe (65 pounds).
6. Cold veneer (40°F.) used and post-press hot-stacking eliminated. This condition designed to create under-cure.

Testing: Twelve test specimens in 2 by 6 and 6 by 6 inches sizes were prepared and tested for each gluing condition The 2 by 6 inch specimens were cyclic tested by means of 4-hour soak at 65°F. water temperature followed by 19 hours of drying at 100°F. The 6 by 6 inch specimens were tested by means of the same soaking cycle but were dried under room atmospheric conditions. Tests were carried out for 15 cycles, with examination of specimens at the end of each drying cycle.

Results: The effectiveness of the 2 by 6 inch specimen and a cycle based on 100°F. drying is compared with that of the 6 by 6 inch specimen and CS45–55 test procedures in Table 3.

Evaluation of data obtained by means of the new 3-cycle test and CS45–55 test as the criterions of glueline quality reveal that only test condition No. 1 showed good performance under the new procedures. All 5 of the defective gluing conditions were

Table 3.—EFFECTIVENESS[1] OF NEW TEST PROCEDURES

	Test Conditions											
	Controls		20 Min TA		30 Min TA		75 Lb. Spread		65 Lb. Spread		Under-cure	
Cycles	2x6	6x6	2x6	6x6	2x6	6x6	2x6	6x6	2x6	6x6	2x6	6x6
	%	%	%	%	%	%	%	%	%	%	%	%
1	100	100	100	100	92	100	100	100	67	100	50	100
2	100	100	100	100	92	100	100	100	8	100	0	100
3	100	100	33	100	58	100	50	100	0	100		92
4	100	100	25	100	33	100	42	100		75		25
5	100	100	0	100	0	100	0	100		50		0
6	100	100		100		100		100		0		
7	58	100		100		83		100				
8	50	100		100		83		100				
9	33	100		100		83		100				
10	33	100		100		83		100				
11	33	100		100		75		100				
12	0	100		100		75		100				
13		100		100		75		100				
14		100		100		75		100				
15		100		100		75		100				

[1]The effectiveness of a new cyclic test is compared with that of old procedures in assessing the effect of gluing defects on glueline quality. Data are recorded as percent of specimens remaining sound at each cycle for all conditions tested. Twelve specimens were tested per condition.

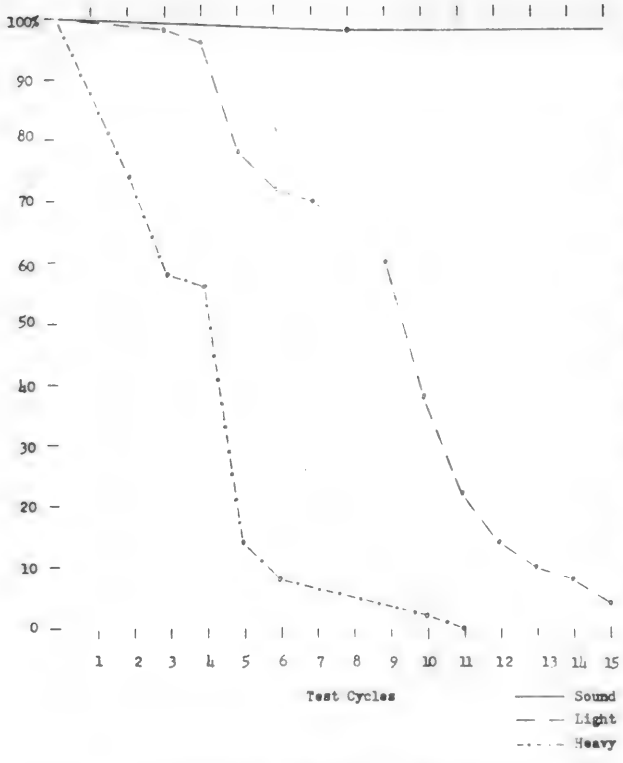


Fig. 5.—Cold-press blood glue, dried at 100° F. Performance and specimens as indicated in Fig. 1.

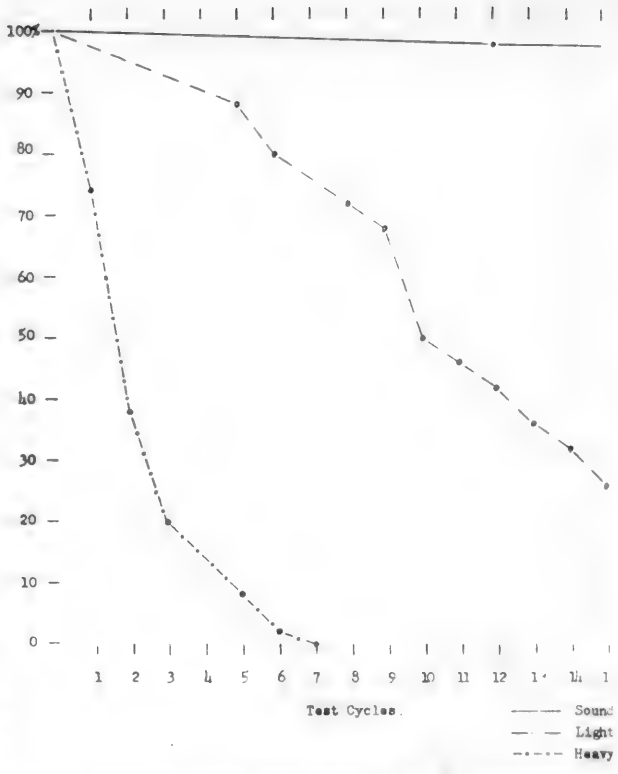


Fig. 6.—Hot-press protein glue, dried at 100° F. Performance and specimens as indicated in Fig. 1.

readily detected by the next test, but only 2 of these conditions (5 and 6) were detected by CS45–55 procedures.

Description of New Test: Two- by five-inch specimens with the grain of the outer plies parallel to length shall be submerged in water at room temperature for 4 hours, then dried at 100° to 105° F. for 19 hours to a maximum moisture content of 8 percent, oven-dry weight. Specimens shall be run through three cycles, unless all have failed. Delamination of ¼ inch in depth and 2 inches in length shall constitute failure. Delamination caused by localized defects other than white pocket permitted within the grade shall disquality the specimen. Finally, 95

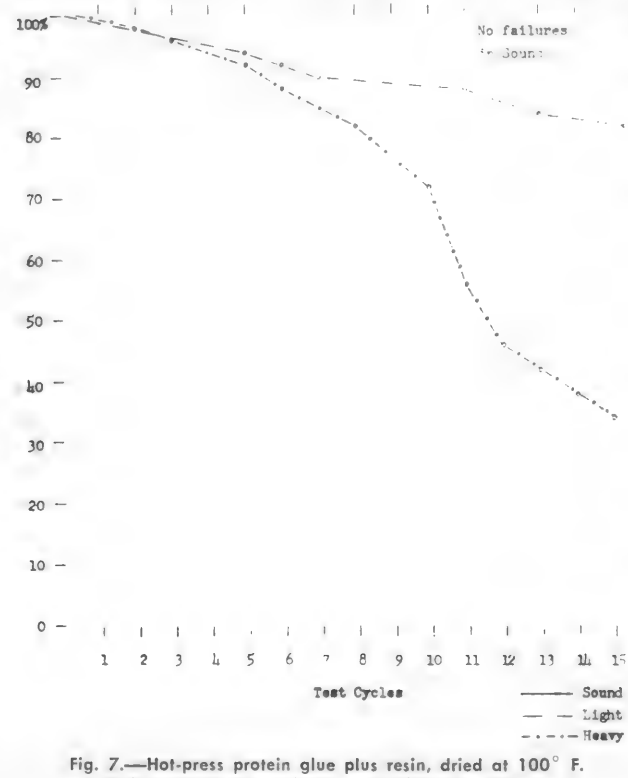


Fig. 7.—Hot-press protein glue plus resin, dried at 100° F. Performance and specimens as indicated in Fig. 1.

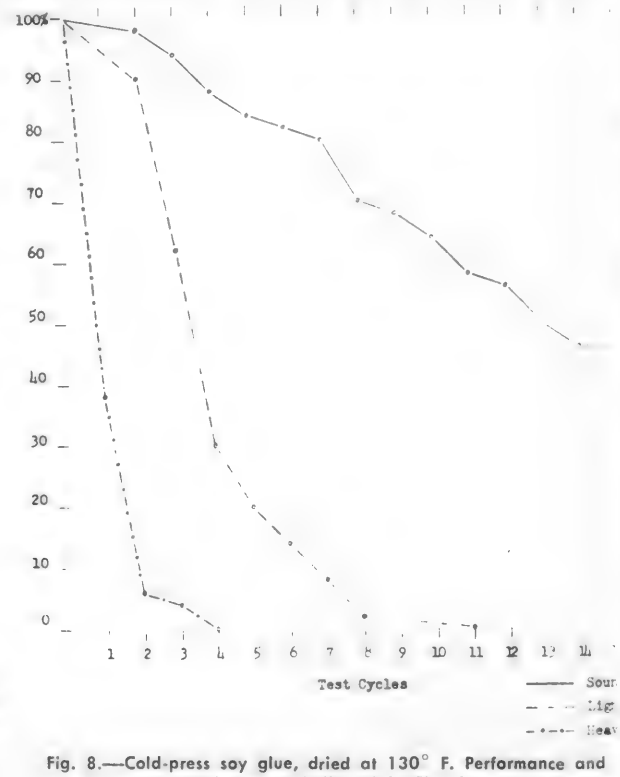


Fig. 8.—Cold-press soy glue, dried at 130° F. Performance and specimens as indicated in Fig. 1.

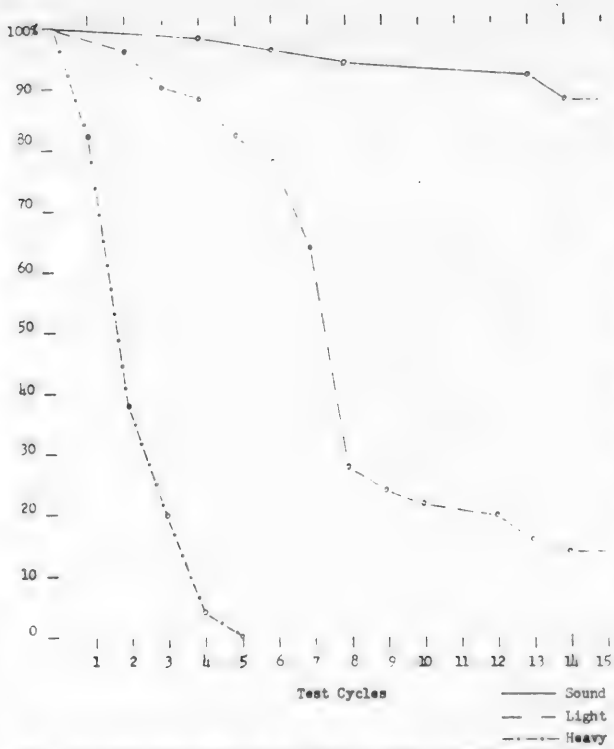


Fig. 9.—Cold-press blood glue, dried at 130° F. Performance and specimens as indicated in Fig. 1.

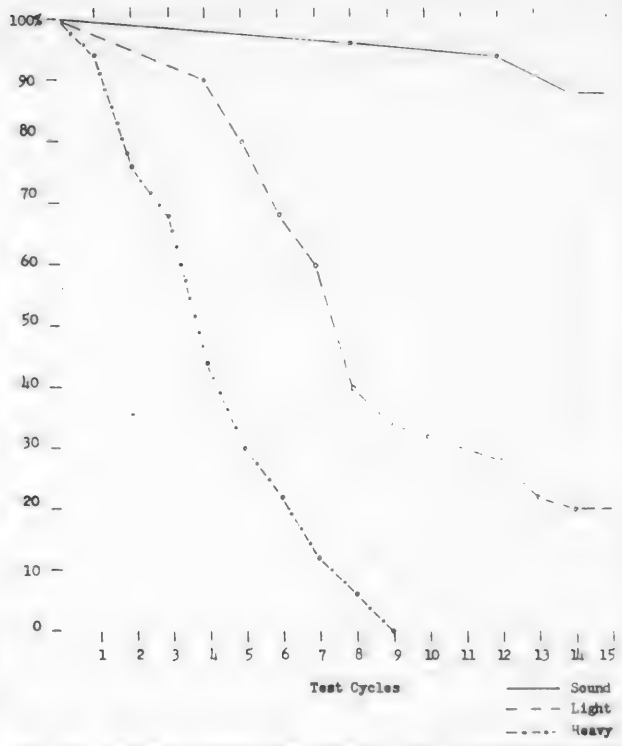


Fig. 10.—Hot-press protein glue, dried at 130° F. Performance and specimens as indicated in Fig. 1.

percent of the specimens shall pass the first cycle, and 85 percent shall pass all three cycles.

Summary

The new test for Interior-type plywood was adopted for DFTA member mills through action by the DFPA Management Committee after consideration of the available information.

It was noted that more efficient drying of test specimens was realized with new equipment installed when the white-pocket gluing study was initiated. The 2 by 5 inch test specimens were consistantly dried to 8 percent moisture content in 19 hours at 100°F. instead of the 11 percent noted in Table 1 for 2 by 6 inch specimens.

The 2 by 5 inch size was adopted because it was more adaptable to the cutting schedule necessary for the routine preparation of test specimens.

The new test procedures appear to answer the problems associated with the old 15-cycle test for Interior-type plywood. They are effective in detecting poor glue bonds, as illustrated in Table 3 and they are effective in detecting bond problems involved with white-pocket veneer. The mechanical equipment necessary to accomplish the drying to 8 percent moisture content is standard, and permits testing to be carried out under reproducible conditions. An additional and important consideration is the speed with which results are made available, compared with the 3-week period required under the old method.

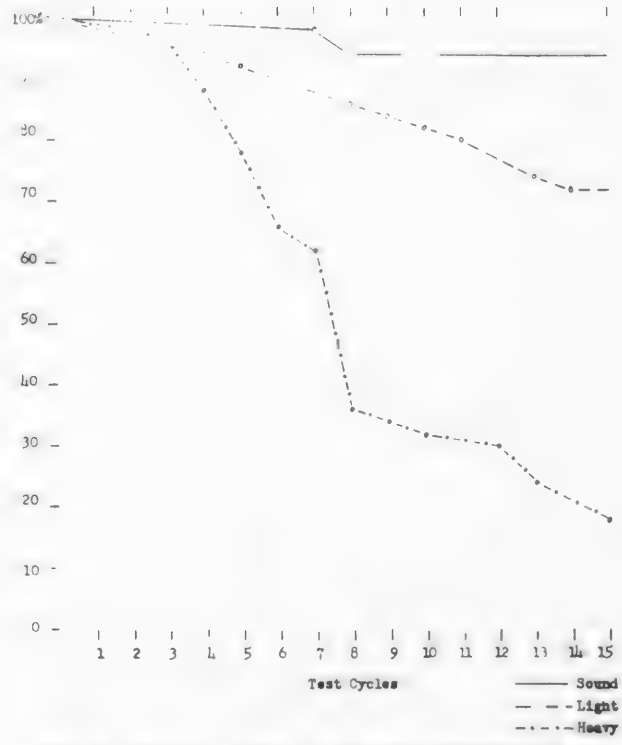


Fig. 11.—Hot-press protein glue plus resin, dried at 130° F. Performance and specimens as indicated in Fig. 1.

Transverse Anisotropy of Wood:

A FUNCTION OF GROSS ANATOMIC STRUCTURE[1,2]

A. P. SCHNIEWIND

University of California Forest Products Laboratory, Richmond

Properties and alignment of the rays were found to be the primary causes of differences between tangential and radial values for modulus of elasticity, tensile strength, and shrinkage in California black oak.

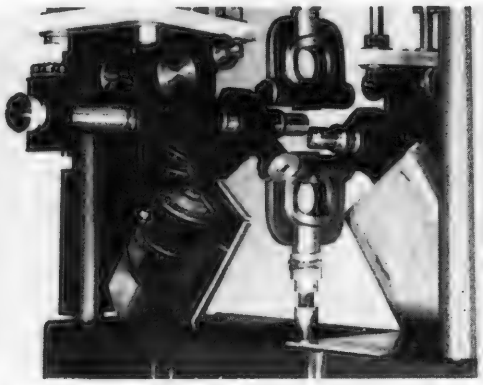


Fig. 1.—Testing machine with optical extensometer. The two microscopes of the extensometer are mounted on a stand, which is fastened to the base of the testing machine.

WOOD IS A HIGHLY anisotropic material. Virtually all its properties differ then tested along different axes. For practical considerations, wood is assumed to have three mutually perpendicular axes of symmetry with respect to its properties—the longitudinal, radial, and tangential axes—with reference to the cylindrical bole of a tree.

The present study deals with anisotropy of three properties in the transverse plane, (the radial-tangential plane): modulus of elasticity, maximum tensile strength, and shrinkage. If a maximum strain theory of failure is assumed for wood, all of these properties deal with deformations—in the first two cases the result of externally applied mechanical forces; in the third, the result of internal forces set up by changes in moisture content. In all cases, the deformations are smaller in the radial than in the tangential direction, which gives a higher modulus of elasticity, higher tensile strength, and a lower shrinkage in the radial direction.

The causes of the anisotropy of deformations in the transverse plane of wood have to be sought in its structure, whether at the gross anatomic, microscopic, or submicroscopic level. The objective of this study was to investigate the influence of gross anatomic structure on the transverse anisotropy of wood by determining, either directly or indirectly, the shrinkage, elastic, and tensile strength properties of the gross anatomic structural components, and then relating these to the properties of whole wood.

The modulus of elasticity of wood is approximately 1.5 to 2 times higher in the radial than in the tangential direction (5)[3]. Price (15) has shown that, on the basis of the mathematical theory of elasticity, the cause of this difference could not be found in the annual ring structure of wood, because the ring structure would be expected to lead to a higher tangential modulus of elasticity. Rather, he attributed it to a high radial modulus of elasticity of the rays and of the prosenchyma cells,[4] the latter resulting from a high degree of radial orientation imposed by the rays. Keylwerth (6), Barkas (1), and Frey–Wyssling and Stuessi (4) came to similar conclusions. McIntosh (9) calculated the ratio of the radial moduli of elasticity of prosenchyma and ray tissue from shrinkage measurements and found it to be 0.181 for red oak and 0.124 for beech, which indicates a considerably higher radial stiffness of the rays as compared with the prosenchyma.

Kollman (7) found that, in a number of species, the radial maximum tensile strength is approximately twice as high as the tangential tensile strength. This he attributed to an inherent weakness of wood in the plane of the rays.

The difference between radial and tangential shrinkage of wood represents a major technological problem to the wood-using industry. The tangential shrinkage[5] of woods grown in the United States ranges from 3.6 to 15.3, and the radial shrinkage from 2.0 to 8.2 per cent (11). Consequently, shrinkage is often accompanied by changes in shape as well as in dimension. Cupping and angular distortions are familiar results of unequal radial and tangential shrinkage.

In contrast to the differences between the radial and tangential modulus of elasticity and tensile strength values, the difference between radial and tangential shrinkage has received considerable attention. Some 50 papers have been published on the subject. In spite of extensive experimentation, however, the mechanism behind differential shrinkage has not been clearly established. Various theories have been advanced in explanation, all based on one or more of the following ideas: 1) the interaction of tissues and cell aggregates that have different shrinkage potentials, particularly the rays and prosenchyma (13) and the earlywood and latewood (18); 2) variations in fibril angles or other properties in the radial and tangential walls of the cells (10, 16); 3) variations in the number and thickness of the middle lamellae, which consist largely of pectic substances of high shrinkage potential, on the radial and tangential interfaces

The Author: Arno Schniewind holds BS, MS, and Phd. degrees in wood technology from the University of Michigan. He is now in charge of research in timber mechanics at the U.C. Laboratory.

[1] First Prize Award, 1959 Wood Award Competition. Presented at Session VIII, Wood Drying, FPRS 13th National Meeting, June 28-July 3, 1959, San Francisco.

[2] Condensation of a thesis submitted in partial fulfillment of the requirements for the PhD degree at the University of Michigan.

[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

[4] The term prosenchyma, as used in this report, refers to all cells other than ray cells. Contrary to strict botanical usage, vertical wood parenchyma are included in the term.

[5] Shrinkage, as referred to in this report, is shrinkage from the green to the oven-dry condition, expressed as a percentage of the dimension when green.

(3); and 4) plastic flow in the cell wall imposed by the restriction of a constant pore volume and exerted mostly in the direction of the lowest stiffness, the tangential direction (6).

Experimental evidence indicates that the most satisfactory explanation of differential shrinkage is to be found in the interaction of the gross anatomic structural components, which differ in their shrinkage potentials. It has been shown conclusively that the radial shrinkage of the rays is less than the radial shrinkage of whole wood (2, 8, 9, 12), and that the shrinkage potential of the earlywood and the latewood are not the same (14, 17). A quantitative evaluation of the effect of these differences has been limited by the lack of data on the elastic properties of the components of wood.

Mathematical Expressions for Transverse Elasticity, Tensile Strength, and Shrinkage of Wood as a Function of the Properties and Relative Proportion of its Gross Anatomic Components

Tangential and Radial Moduli of Elasticity: Ylinen (21) derived equations 1 and 2[6] for the tangential and radial moduli of elasticity by considering wood as a laminate of alternating layers of transversely anisotropic earlywood and latewood.

These equations are approximations obtained by omission of relatively minor terms that involve Poisson's ratios. Ylinen found that, for Finnish pine, the omission of these terms introduces an error of less than one percent in the calculated values.

Ylinen did not attempt to explain the elastic anisotropy, nor did he take any possible effect of the rays into consideration. This can be done by deriving expressions for the earlywood and the latewood by considering each of these as a laminate of alternating layers of ray tissue and prosenchyma, and substituting these into Ylinen's equations. Wood is then considered as a complex laminate with two successive stages of lamination perpendicular to each other. It is assumed that the properties of the rays are not affected by their position within the annual ring, that the rays have their highest stiffness in the radial direction, and that their tangential stiffness is more closely similar to that of the prosenchyma. The earlywood prosenchyma and the latewood prosenchyma, taken separately, are assumed to be isotropic in the transverse plane.

By analogy to Ylinen's equations, expressions for the radial and tangential moduli of elasticity of the earlywood and the latewood can now be derived as given by equations 3, 4, 5, and 6.

Substitution of equations 3 and 4 into equation 1 gives the final expression for E_T, equation 7.

Similarly, substitution of equations 5 and 6 into equation 2 gives the final expression for E_R, equation 8.

Tangential and Radial Tensile Strength: Expressions for radial and tangential maximum tensile strength can be derived on the same basis as for modulus of elasticity. Failure in the radial plane as a result of tangential stress may occur either in the rays or in the prosenchyma. If the failure occurs in the rays, the tangential tensile strength will be governed by the strength of the rays. On the other hand, if the failure occurs in the prosenchyma, three posibilities exist: a) the earlywood will fail first; b) the latewood will fail first; or c) the earlywood and the latewood will fail simultaneously. If the last case holds, the tangential strength can be expressed as a function of the proportion of latewood as given by equation 9.[7]

Ylinen (19, 20) has presented some evidence that such an approach may be justified. If either the earlywood prosenchyma or the latewood prosenchyma fails first, mathematical analysis on the basis of the simple terms presented here is not possible.

Failure in the tangential plane as a result of radial stress must be expected in the earlywood. Here again, the rays may fail first, the earlywood prosenchyma may fail first, or they may both fail simultaneously. If the last case holds, the radial tensile strength can be expressed as a function of the proportion of ray tissue as given by equation 10.

The expressions for tangential and radial maximum tensile strength are based on assumptions that have been selected from a number of alternatives on the basis of limited evidence (19, 20) and because they lend themselves to simple mathematical analysis. This, however, does not preclude the possibility that the assumptions are valid.

Radial and Tangential Shrinkage: Unequal shrinkage of anatomic components must result in stresses and strains. Mathematical expressions for radial and tangential shrinkage can therefore be derived on the same general basis as that used for the mechanical properties. Equations 11 through 16 are based on the work of McIntosh (9), who considered only the interaction of the rays and the prosenchyma, and on the work of Pentoney (14), who considered only the interaction of earlywood and latewood. Equations that take both factors into consideration have not been previously presented.

When a relatively large piece of earlywood shrinks, the prosenchyma and the rays are forced to shrink together in the radial direction, and because of unequal shrinkage, the prosenchyma will be in tension and the rays in compression. The radial shrinkage of the earlywood can then be expressed by equation 11.

The radial shrinkage of the latewood can be expressed similiary by equation 12.

The tangential shrinkage of the earlywood can occur unrestrained, and is equal to the sum of the ray tissue and prosenchyma shrinkages, plus Poisson's effects that arise from the stresses in the radial direction, and can be expressed by equation 13.

The tangential shrinkage of the latewood is expressed similarly by equation 14.

By treating the earlywood and the latewood as if they were homogeneous, expressions can be derived for the radial and tangential shrinkage of whole wood in terms of the shrinkage properties of these two components. The expression for the tangential shrinkage of whole wood is analogous to that of the radial shrinkage of earlywood or latewood, and is given by equation 15.

The expression for the radial shrinkage of whole wood is analogous to that of the tangential shrinkage of the earlywood or the latewood, and is given by equation 16.

[7] Equations 9 and 10 are based on the work of Ylinen on strength properties parallel to grain (20), and are derived by analogy to his work.

WHAT THIS RESEARCH MEANS

Wood exhibits different properties along axes in different directions. The reasons for the difference in properties, such as shrinkage and strength, between the radial and tangential axes in the transverse plane has not been clear. From a practical aspect, one of the most important consequences is that of warping and checking as a result of differences in shrinkage along different axes. This paper develops a basic approach to the cause of these differences to gain a more thorough understanding of the complex behavior of wood. By applying mathematical relationships to predict bulk wood shrinkage from experimentally derived shrinkage and strength values of ray and vertical tissue, ray tissue was found to be the primary cause of property differences between radial and tangential axes. This relationship also has implications with respect to an understanding of the mechanisms of the deformation of wood as a whole, involving better appreciation of characteristics such as shrinkage and behavior of wood under load. The approach adapted also points to the desirability of further study on the individual tissues of which bulk wood is comprised.

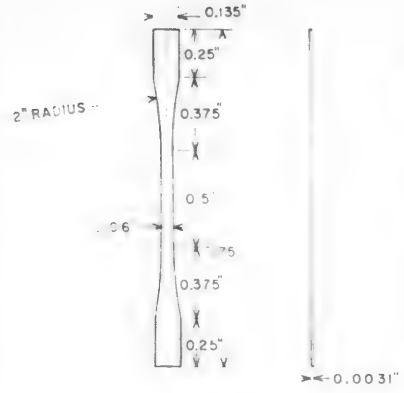


Fig. 2.—Shape and dimensions of the micro-tensile test specimen.

Transverse Elasticity and Tensile Strength of the Anatomic Components

Procedure: To investigate the validity of equations 1 through 10, a series of micro-tensile tests were made at 6 and 12 percent moisture content and in the green condition. California black oak (*Quercus kelloggii* Newb.) was chosen for the experimental work because it has well-developed rays and pronounced differences in the structure of the earlywood and the latewood. The material was taken from five different trees.

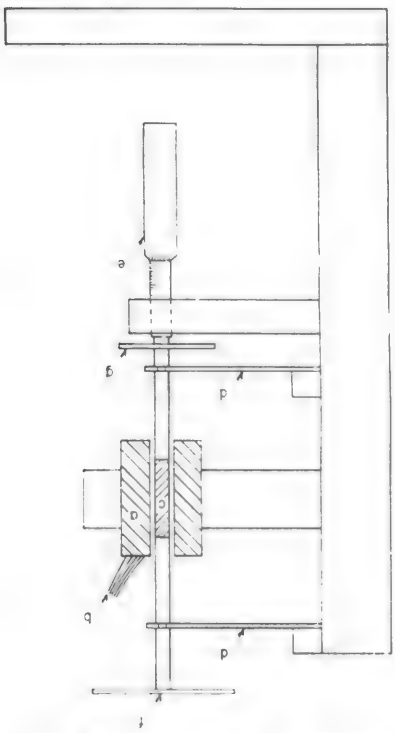


Fig. 3.—Thickness gauge for micro-tensile test specimens. a: differential transformer shell; b: leads to indicator; c: differential transformer core; d: leaf springs; e: micrometer head; f: platter for weights; g: specimen.

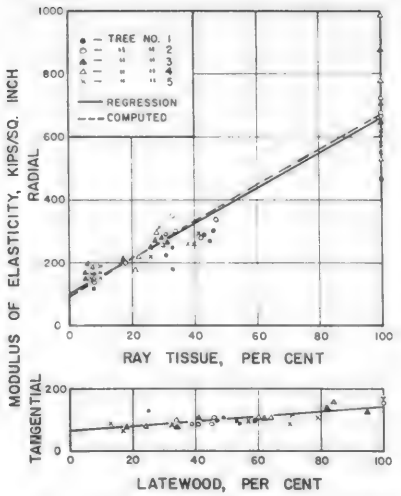


Fig. 4.—Radial and tangential modulus of elasticity from micro-tensile tests as a function of the ray tissue and latewood percentage, respectively, at 6 percent moisture content. All points are individual data. The solid lines are from the regression equations. Points of the broken line were computed from the properties of pure ray tissue and the results of tangential tests.

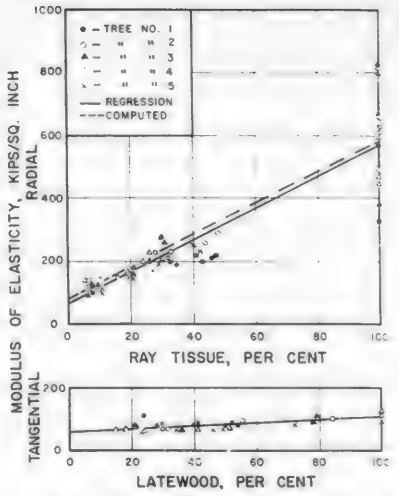


Fig. 5.—Radial and tangential modulus of elasticity from micro-tensile tests as a function of ray tissue and latewood percentage, respectively, at 12 percent moisture content. Data plotted as indicated in Fig. 4.

At each moisture content level, 15 specimens consisting entirely of ray tissue and 40 specimens containing various proportions of ray tissue and prosenchyma were tested in the radial direction, and 30 specimens containing varying proportions of latewood were tested in the tangential direction. The shape and dimensions of the specimens are shown in Fig. 2. The specimens were prepared by cutting microtome sections from the green wood, drying the specimen blanks (where required) to the desired moisture content between teflon-covered blocks (to keep the sections flat; the teflon minimizes friction), and cutting the specimens to final dimensions with a special die immediately before each test.

The actual dimensions of each specimen in the area of reduced cross-section were determined by measuring the width microscopically, and the thickness with a device developed for this study to over-come the inherent problems of measuring small dimensions of deformable material. The device, shown diagrammatically in Fig. 3, consists of a differential transformer, with shell *a* and core *c*, as the transducer. The shell is fixed to the stand and the core is suspended vertically from leaf springs *d*. The core extensions terminate in a platter *f* for weights, above, and a slightly rounded probe, below. The probe is directly above the flat anvil of micrometer head *e*, and the specimen *g* is inserted between anvil and probe. The leads *b* connect the differential transformer to an indicator. Thickness can be read to the nearest 25 microinches with this system.

To make a thickness measurement, the specimen is inserted, and a weight of 200 grams, is placed on the platter. A thickness reading to the nearest 25 microinches is taken, and an additional 200-gram. weight is placed on the platter. The first and second thickness readings give two points on a line that represents thickness as a function of actuating force. If a straight-line relationship is assumed, the thickness at zero actuating force can be obtained by extrapolation.

For the measurement of extension of the micro-tension specimens during tests, the optical extensometer shown in Fig. 1 was designed and constructed. It consists essentially of two metallurgical microscopes with vertical illuminators for observation in reflected light. The microscopes are mounted on a stand fastened to the base of the testing machine. The optical axes of the microscopes are parallel and offset by 0.4 inch, the gauge length.

The principle of operation of the extensometer is very simple. A gauge point represented by an anatomic feature of the specimen is selected in the field of view of each microscope. During a test, the upper point will be displaced within the field of view by an amount equal to the deflection of the machine plus the extension of that part of the specimen located between the upper grip and the gauge point. The displacement of the point in the lower field of view is equal to the displacement of the upper point plus the extension of the specimen between gauge points. The difference between the displacements of the upper and lower gauge points therefore gives the extension of the specimen over the central gauge length.

Each microscope has a 20X objective and a filar micrometer eyepiece. Each

List of Equations

$$E_T = E_{Te} + (E_{T_1} - E_{Te})P_1 \quad \text{(Eq. 1)},$$

$$E_R = \frac{E_{Re}E_{R_1}}{E_{R_1} - (E_{R_1} - E_{Re})P_1} \quad \text{(Eq. 2)},$$

$$E_{Te} = \frac{E_eE_{Tr}}{E_{Tr} - (E_{Tr} - E_e)P_r} \quad \text{(Eq. 3)},$$

$$E_{T_1} = \frac{E_1E_{Tr}}{E_{Tr} - (E_{Tr} - E_1)P_r} \quad \text{(Eq. 4)},$$

$$E_{Re} = E_e + (E_{Rr} - E_e)P_r \quad \text{(Eq. 5)},$$

$$E_{R_1} = E_1 + (E_{Rr} - E_1)P_r \quad \text{(Eq. 6)},$$

$$E_T = \frac{E_eE_{Tr}(1 - P_1)}{E_{Tr} - (E_{Tr} - E_e)P_r} + \frac{E_1E_{Tr}P_1}{E_{Tr} - (E_{Tr} - E_1)P_r} \quad \text{(Eq. 7)},$$

$$E_R = \frac{[E_1 + (E_{Rr} - E_1)P_r][E_e + (E_{Rr} - E_e)P_r]}{(1 - P_1)[E_1 + (E_{Rr} - E_1)P_r] + P_1[E_e + (E_{Rr} - E_1)P_r]} \quad \text{(Eq. 8)}.$$

$$\sigma_{TM} = \sigma_{eM}(1-P_1) + \sigma_{1M}P_1 \quad \text{(Eq. 9)},$$

$$\sigma_{RM} = \sigma_{eM}(1-P_r) + \sigma_{RrM}P_r \quad \text{(Eq. 10)},$$

$$S_{Re} = \frac{(1 - P_r)R\,S_e(1 - S_{Rr}) + P_rS_{Rr}(1 - S_e)}{(1 - P_r)R\,(1 - S_{Rr}) + P_r(1 - S_e)} \quad \text{(Eq. 11)},$$

$$S_{R_1} = \frac{(1 - P_r)R'S_1(1 - S_{Rr}) + P_rS_{Rr}(1 - S_1)}{(1 - P_r)R'\,(1 - S_{Rr}) + P_r(1 - S_1)} \quad \text{(Eq. 12)},$$

$$S_{Te} = \frac{[(1 - P_r)R(1 - S_{Rr})\,P_r(1 - S_e)][(1 - P_r)S_e + P_rS_{Tr}] + M}{(1 - P_r)R(1 - S_{Rr}) + P_r(1 - S_e)} \quad \text{(Eq. 13)},$$

$$S_{T_1} = \frac{[(1 - P_r)R'(1 - S_{Rr}) + P_r(1 - S_1)][(1 - P_r)S_1 + P_rS_{Tr}] + N}{(1 - P_r)R'(1 - S_{Rr}) + P_r(1 - S_1)} \quad \text{(Eq. 14)},$$

$$S_T = \frac{(1 - P_1)R''S_{Te}(1 - S_{T_1}) + P_1S_{T_1}(1 - S_{Te})}{(1 - P_1)R''(1 - S_{T_1}) + P_1(1 - S_{Te})} \quad \text{(Eq. 15)},$$

$$S_R = \frac{[(1 - P_1)R''(1 - S_{T_1}) + P_1(1 - S_{Te})][(1 - P_1)S_{Re} + P_1S_{R_1}] + Q}{(1 - P_1)R''(1 - S_{T_1}) + P_1(1 - S_{Te})} \quad \text{(Eq. 16)},$$

where

$M = P_r(1 - P_r)(S_e - S_{Rr})\,[\mu_p(1 - S_e) - \mu_{RTr}R(1 - S_{Tr})]$

$N = P_r(1 - P_r)(S_1 - S_{Rr})\,[\mu_p(1 - S_1) - \mu_{RTr}R'\,(1 - S_{Tr})]$

$Q = \mu_{TR}P_1(1 - P_1)(S_{Te}[(1 - S_{Re}) - R''\,(1 - S_{R_1})]$

E_T = tangential modulus of elasticity of whole wood

E_R = radial modulus of elasticity of whole wood

E_{Te} = tangential modulus of elasticity of earlywood

E_{Re} = radial modulus of elasticity of earlywood

E_{T_1} = tangential modulus of elasticity of latewood

E_{R_1} = radial modulus of elasticity of latewood

E_e = transverse modulus of elasticity of earlywood prosenchyma

E_1 = transverse modulus of elasticity of latewood prosenchyma

E_{Tr} = tangential modulus of elasticity of ray tissue

E_{Rr} = radial modulus of elasticity of ray tissue

P_r = relative proportion of ray tissue

P_1 = relative proportion of latewood

σ_{TM} = tangential maximum tensile strength of whole wood

σ_{eM} = transverse maximum tensile strength of earlywood

σ_{1M} = transverse maximum tensile strength of latewood

σ_{RM} = radial maximum tensile strength of whole wood, and

σ_{RrM} = radial maximum tensile strength of ray tissue

S_{Re} = unit radial shrinkage of the earlywood

S_e = unit transverse shrinkage of the earlywood prosenchyma

S_{Rr} = unit radial shrinkage of the ray tissue

S_{R_1} = unit radial shrinkage of the latewood

S_1 = unit transverse shrinkage of the latewood prosenchyma

S_{Te} = unit tangential shrinkage of the earlywood

S_{Tr} = unit tangential shrinkage of the ray tissue

S_{T_1} = unit tangential shrinkage of the latewood

S_R = unit radial shrinkage of whole wood

S_T = unit tangential shrinkage of whole wood

R = ratio of the moduli of elasticity of the earlywood prosenchyma (transverse) and the ray tissue (radial)

R' = ratio of the moduli of elasticity of the latewood prosenchyma (transverse) and the ray tissue (radial)

R'' = ratio of the tangential moduli of elasticity of earlywood and latewood

μ_p = Poisson's ratio of the prosenchyma (either type) in the transverse plane

μ_{RTr} = Poisson's ratio of the ray tissue for tangential strain due to radial strain

μ_{TR} = Poisson's ratio of earlywood and latewood for radial strain due to tangential strain

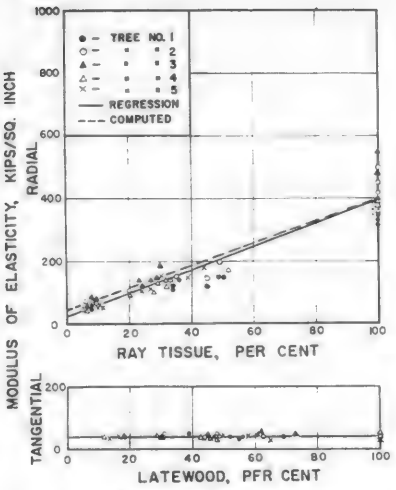


Fig. 6.—Radial and tangential modulus of elasticity from micro-tensile tests as a function of ray tissue and latewood percentage, respectively, in the green condition. Data plotted as indicated in Fig. 4.

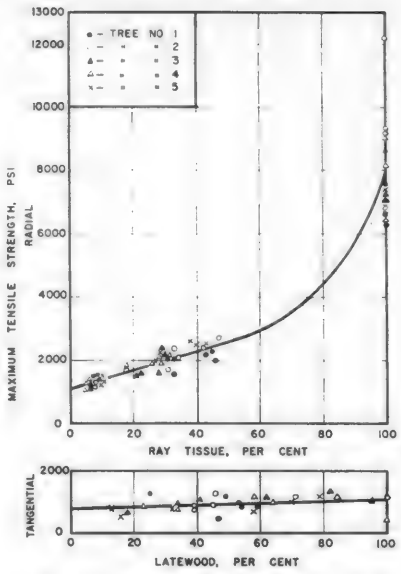


Fig. 7.—Radial and tangential tensile strength as a function of ray tissue and latewood percentage, respectively, at 6 percnet moisture content. The tangential data were fitted by regession, and the radial data were fitted freehand. All points are individual data.

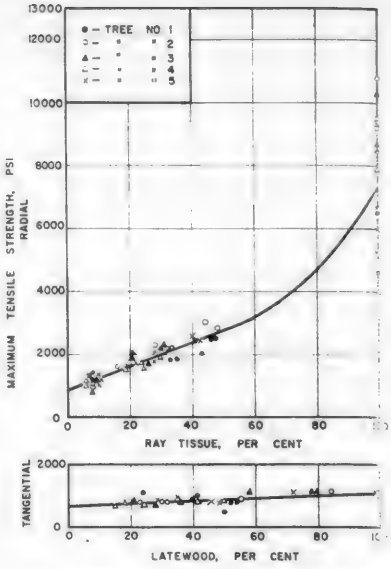


Fig. 8.—Radial and tangential tensile strength as a function of ray tissue and latewood percentage, respectively, at 12 per cent moisture content. Data plotted as indicated in Fig. 7.

system was calibrated with a stage micrometer inserted in the grips in place of the specimen. Strain over the nominal gauge length can be determined to the nearest 46 x 10^{-6} inch per inch. The actual gauge length, that is, the distance from center to center of the two fields of view, was also calibrated with a stage micrometer.

The optical extensometer could not be used for tests on wood in the green condition, because a free film of water had to be maintained on the green specimens to keep them from drying during the test. Preliminary examination showed that this film of water reflected all of the incoming light; consequently the image of the water surface completely obscured all specimen detail. Transmitted light could not be used because of space limitations. It was therefore decided to estimate the modulus of elasticity values in the green condition from over-all extension of the specimens as obtained from the crosshead movement.

The micro-tensile tests were performed on an Instron Tensile Tester. Two operators were required to take simultaneous readings of the displacements of the gauge points and load at regular intervals. The tests at nominal moisture contents of 6 and 12 percent were performed in controlled-environment rooms with equilibrium moisture content conditions equal to the desired nominal moisture content. After each test, the proportion of ray tissue in the radial specimens and the proportion of latewood in the tangential specimens were determined by microscopic measurement.

Results and Discussion—Modulus of Elasticity Values: The results of the tests at 6 and 12 percent moisture content showed very good correlation, regardless of specimen type, between the modulus of elasticity values obtained with the optical extensometer and those obtained from over-all extension. The relationship between the two types of modulus of elasticity values, however, was found to depend on moisture content. Since the relationships showed very good correlation at a given moisture content, it was decided to analyze the modulus of elasticity data for specimens in the green condition without adjustment, along with the other data, on the basis that the former were the best available estimate of the true values.

According to equation 7, the tangential modulus of elasticity is a linear function of the proportion of latewood if all other terms of the equation are constant. Regression equations were computed for each of the three moisture-content levels, and the regression lines are shown in Figs. 4, 5, and 6. Table 1 shows the modulus of elasticity values of earlywood, whole wood, and latewood as computed from the regression equations. The values for whole wood are based on an average latewood percentage of 56.3 of the experimental material as determined by microscopic measurement. The latewood in each case has the higher value, probably the result of its higher density. The slope of the regression lines is significantly difference from zero (at the 5 percent level) at 6 and 12 percent moisture content, but not significantly different from zero in the green condition, which indicates a significant difference between the property values of the earlywood and the latewood at the lower moisture contents.

According to equation 8, the radial modulus of elasticity is not a linear function of the proportion of ray tissue. It can be shown, however, that if the different between E_e and E_l is small compared with the difference between E_{Rr} and either one of the former terms, the relationship can be approximated very closely by a straight line. For the material under investigation, this condition appeared to be fulfilled, and linear regression lines were computed accordingly. The regression lines are shown in Figs. 4, 5, and 6 in the form of solid lines.

The radial modulus of elasticity values of prosenchyma, whole wood, and ray tissue, as computed from the regression equations, are shown in Table 2. The figures for whole wood were computed on the basis of 17.0 percent ray tissue as the average value for the experimental material, as determined by microscopic measurements. The figures for prosenchyma have no meaning in terms of the theoretical equations, but are shown here to illustrate 1) the considerable difference in stiffness between the rays and the prosenchyma, and 2) that the properties of the prosenchyma in the radial direction are lower than the properties of whole wood in the tangential direction. If it is assumed that the tangential properties of whole wood are independent of the properties of the rays, the latter finding is consistent with the observation of Price (15) that wood consisting solely of isotropic latewood and isotropic earlywood should have a

lower radial modulus of elasticity. The ratios of the figures for the prosenchyma to those of the ray tissue are 0.060, 0.112, and 0.149, respectively, in the green condition and at 12 and 6 percent moisture content. These ratios, especially at the lower moisture contents, are of the same order of magnitude as those obtained by McIntosh from shrinkage measurements of red oak and beech (9).

Direct substitution of the experimental data in equations 7 and 8 is not possible because all of the terms of equations could not be obtained from the experiments. The missing terms are E_{Tr}, E_e, and E_l. Since figures were available for E_{Te} and E_{Tl}, the terms E_e and E_l could be calculated from equations 3 and 4 if E_{Tr} were known. The tangential modulus of elasticity of the ray tissues as it might have been obtained from micro-tensile tests was assumed to be 42, 80, and 110 ksi, respectively, in the green condition and at 12 and 6 percent moisture content. The experimental and assumed values were substituted in equations 3 and 4, and these were solved for the transverse modulus of elasticity of the earlywood prosenchyma and the latewood prosenchyma, respectively. The calculated values of E_e and E_l, the radial modulus of elasticity figures of the ray tissue,[8] and the fractional proportion of latewood (0.563) were substituted in equation 8, and radial modulus of elasticity values were calculated for various values of the fractional proportion of ray tissue. The calculated points were plotted in Figs. 4, 5, and 6, and connected by a broken line. The agreement with the regression lines is very good. For the most part, the computed curves are above the regression lines, which indicates that, according to the theoretical relationships, the transverse elastic anisotropy would be expected to be somewhat higher than it actually is.

It can therefore be concluded that the earlywood prosenchyma and the latewood prosenchyma are essentially isotropic in the transverse plane, and that the difference between the radial and the tangential moduli of elasticity of whole wood is the result of the transverse anisotropy of the ray tissue. The difference between the elastic properties of the isotropic earlywood prosenchyma and the isotropic latewood prosenchyma counteracts the effect of the rays to some extent.

Results and Discussion—Maximum Tensile Strength: The tangential maximum tensile strength, according to equation 9, is a linear function of the latewood percentage. Regression equations were computed for the three moisture-content levels, and the regression lines are shown in Figs. 7, 8, and 9. Table 3 shows the tangential tensile strength of earlywood, whole wood, and latewood as computed from the regression equations. The slope of the regression equations was signficantly different from zero in all cases at the 5 percent level or better. Therefore the tensile strengths of the earlywood and the latewood differ significantly. The application of equation 9 to the tangential data appears to be justified. This is further supported by the observation that the failure occurred in the prosenchyma in the majority of the cases.

The tangential maximum tensile strength of the earlywood and the latewood increases as the moisture content is decreased, but the tensile strength of the latewood is almost exactly the same at 6 and 12 percent moisture content. The lack of a difference might be due to increased residual shear stresses caused by unequal shrinkage of the rays and the prosenchyma. This is illustrated in Fig. 10, which shows three serial sections each containing a board ray. Section *a* (top) was dried in the form in which it is shown, with the broad ray in the center of the section, and remained straight. Section *b* (middle) was also dried in the form in which it is shown, with the broad ray along one edge. Because of a high shrinkage of the prosenchyma and a shrinkage of the broad ray (radial direction), the section has curved considerably, Section *c* (bottom) in two parts, was dried in the same form as Section *a*, and was originally straight after it was dried. It was then cut lengthwise so that part of it had the broad ray along one edge. It can be seen that this section also curved, although not so much as Section *b*. This series of sections shows that, because of unequal shrinkage, the rays are under compression and the prosenchyma under tension. It appears that some of the stresses are relieved by plastic flow, but a certain amount of residual stresses remains. In a large piece of wood, therefore, shear stresses exist at the ray-prosenchyma interface According to the laws of mechanics, the presence of shear stress in addition to the normal stress increases the principal stress. Since the shear stresses in wood increase at the lower moisture content, they will at least in part offset the gain in strength that results from normal loss of moisture. The operation of such a factor would also be greatest where the shrinkage differential is greatest, namely, in the latewood.

The radial maximum tensile strength, according to equation 10, is a linear function of the ray tissue percentage. This appears to hold only for the data for specimens in the green condition. The radial tensile strength data were therefore fitted freehand. The curves are shown in Figs. 7, 8, 9. At 6 and 12 percent moisture content, the relationship appears to be linear up to approximately 50 percent ray tissue, and becomes concave upward beyond that point. The probable explanation of the observed relationships is as follows: For specimens in the green condition, no internal stresses from unequal shrinkage exist, and the relationship is as predicted. At the lower moisture contents, the prosenchyma have been prestressed in tension parallel to the direction of test. Maximum strain will therefore be reached in the prosenchyma first, and failure will occur at a lower stress level than expected. Wood may here be likened to a tension member of prestressed concrete in which, by an unfortunate accident, the concrete, instead of the steel members, has been prestressed in tension.

Table 4 shows the radial maximum tensile strength figures as read from the freehand curves. According to equations 9 and 10, the tensile strength of the prosenchyma in the radial direction should be equal to the tensile strength of the earlywood. Comparison with the tangential tensile strength of

[8] Direct averages were used. They differ slightly from the values computed from the regression equations.

Table 1.—TANGENTIAL MODULUS OF ELASTICITY OF EARLYWOOD, WHOLE WOOD, AND LATEWOOD FROM THE REGRESSION EQUATIONS, AT THREE LEVELS OF MOISTURE CONTENT

Moisture content	Earlywood, ksi* Mean	Earlywood, ksi* Standard error	Whole wood, ksi Mean	Whole wood, ksi Standard error	Latewood, ksi Mean	Latewood, ksi Standard error
per cent	65 2	2.97	199.8	7.59	144.5	12.75
2 percent	53.5	2.00	85.0	4 99	105 6	8.36
Green	40.7	0.94	43.0	2.51	44.7	4.25

*The abbreviations ksi and kips/sq. in. for kilopounds (1000 lbs.) per square ch are used in this report.

Table 2.—RADIAL MODULUS OF ELASTICITY OF PROSENCHYMA, WHOLE WOOD, AND RAY TISSUE FROM THE REGRESSION EQUATIONS, AT THREE LEVELS OF MOISTURE CONTENT

Moisture conent	Prosenchyma, ksi Mean	Prosenchyma, ksi Standard error	Whole wood, ksi Mean	Whole wood, ksi Standard error	Ray tissue, ksi Mean	Ray tissue, ksi Standard error
6 percent	98.5	10.54	193.7	11.68	659	31.47
12 percent	64.3	11.51	150.6	12.74	572	34.15
Green	23.7	5.66	86.5	6.27	393	16.89

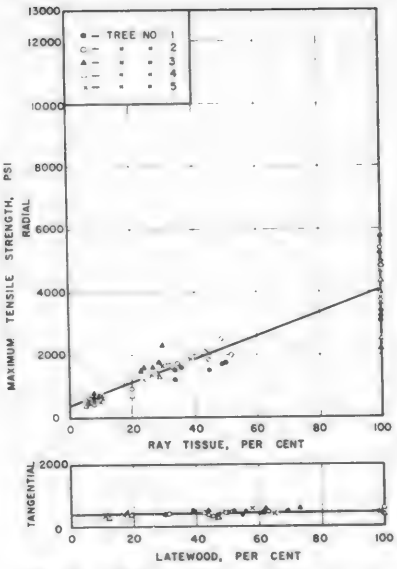


Fig. 9.—Radial and tangential tensile strength as a function of ray tissue and latewood percentage, respectively, in the green condition. Data plotted as indicated in Fig. 7.

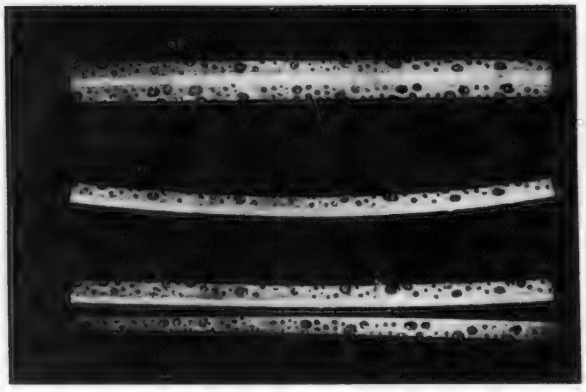


Fig. 10.—These aerial sections illustrate internal shrinkage stresses after they were dried to 8 percent moisture content. Top: balanced; middle: unbalanced before drying; bottom: unbalanced after drying.

earlywood (Table 3) shows that, in the green condition, the radial figure is lower, whereas at 6 and 12 percent moisture content the radial figures are higher. In view of the complications apparently introduced by internal stresses at the lower moisture contents, it is difficult to arrive at a conclusion on the isotropy or anisotropy of the earlywood with respect to maximum tensile strength. For specimens in the green condition, the assumption of isotropy appears to be justified.

The radial maximum tensile strength of whole wood in the green condition was calculated from equation 10 by substituting the tensile strength of the earlywood prosenchyma as obtained from tangential tests, the radial maximum tensile strength of the ray tissue as measured directly, and the average fractional proportion of ray tissue (0.17). The calculated figure for whole wood was 1,020 psi, as compared with 990 psi obtained by direct measurement. It can therefore be concluded that the difference between radial and tangential tensile strength of California black oak is primarily the result of the high radial tensile strength of the ray tissue. To evaluate the effect of the rays quantitatively at moisture contents below the fiber saturation point, the equations presented in this report would have to be modified to take additional factors, probably internal stresses, into consideration.

Size Factors: A series of macro-tensile tests were made on specimens similar in shape to the specimen shown in Fig. 2, but with a minimum cross section of 0.3 by 0.25 inch. Comparison of the results of these tests with the results obtained from micro-tensile tests (whole wood values as computed from the various regression equations) showed that a size factor of considerable magnitude influenced the results. The ratios of the micro-tensile to the macro-tensile test results ranged from 0.43 to 0.62 for the modulus of elasticity data, and from 0.54 to 0.78 for the maximum tensile strength data. The cause of the lower micro-tensile test data could not be determined, but is probably related to the size of the specimens, which includes edge effects that are of little importance in larger specimens. The degree of anisotropy was approximately the same for both methods of test, however, and the micro-tensile test data may be considered internally consistent. The conclusions drawn from these data, therefore, are not affected by their generally low magnitude.

Radial and Tangential Shrinkage of the Components

Procedure: Measurements of shrinkage from green to oven-dry were made on micro-shrinkage specimens to obtain radial and tangential shrinkage figures for ray tissue, earlywood, and latewood, for an experimental evaluation of equations 11, 12, 13, 14, 15, and 16. Radial and tangential shrinkage was measured on the same specimens. Five types of specimens were used: pure ray tissue, earlywood and latewood free of broad rays, and earlywood and latewood including a broad ray. Shrinkage determinations were made on 15 specimens of each type.

The micro-shrinkage specimens were prepared on the microtome by cutting transverse sections 80 microns thick. The radial and tangential dimensions of the specimens were both approximately 0.03 inch. In most cases, the tangential dimension of the specimens of pure ray tissue was less because their dimension was governed by the width of the broad rays.

Measurements were made under the microscope, at 125 diameters, with a filar micrometer eye-piece. The measurements could be made to the nearest 0.1 percent of the green dimension in most cases, but only to the nearest 0.3 percent for the tangential measurements of some of the specimens of pure ray tissue. The measurements were made between distinctive features of the anatomy of the specimen located some distance from the edge, to avoid errors as a result of edge effects, and because the edges tended to be somewhat ill-defined. The points of measurements were marked on photomicrographs for relocation after shrinkage. The percentage of ray tissue of each specimen was measured at the same time.

Results and Discussion: Results of the micro-shrinkage measurements are summarized in Table 5 and shown graphically in Figs. 11 and 12. Since

Table 3.—TANGENTIAL MAXIMUM TENSILE STRENGTH OF EARLYWOOD, WHOLE WOOD, AND LATEWOOD FROM THE REGRESSION EQUATIONS, AT THREE LEVELS OF MOISTURE CONTENT

Moisture content	Earlywood, psi		Whole wood, psi		Latewood, psi	
	Mean	Standard error	Mean	Standard error		Standard error
6 percent	814	41.7	991	106.4	1,128	178.9
12 percent	683	25.1	932	62.4	1,126	104.6
Green	391	12.1	457	32.2	508	54.4

Table 4.—RADIAL MAXIMUM TENSILE STRENGTH OF PROSENCHYMA WHOLE WOOD, AND RAY TISSUE AS READ FROM THE FREE-HAND CURVES, AT THREE LEVELS OF MOISTURE CONTENT

Moisture content	Prosenchyma, psi	Whole wood, psi	Ray tissue, psi
6 percent	1,100	1,600	7,970
12 percent	860	1,500	7,390
Green	350	990	4,090

no distinction was made between ray tissue in earlywood and in latewood, the points for 100 percent ray tissue are the same in both figures. The scatter of the data is large, and on a much higher order of magnitude than the probable error, which ranged from 0.1 to 0.3 percent shrinkage. The wide scatter did not appear to be the result of imperfections in the technique. A more probable explanation might be found in edge effects and the occurrence of partial cells on the edges. Because of the small size of the specimens and the occurrence of partial cells, which could be minimized but not entirely avoided, the distribution of stresses caused by unequal shrinkage was probably not the same as it would have been if the specimen material had been contained in a large piece of wood.

The micro-shrinkage data in Table 5 show that the ray tissue has the lowest radial shrinkage, and its magnitude agrees well with the results of other investigators (2, 8, 9, 12). The latewood has the highest radial and tangential shrinkage, as might also be expected. In the earlywood and the latewood, the specimens with a broad ray had a lower radial shrinkage and a higher tangential shrinkage than did those without a broad ray. The higher tangential shrinkage was not the result of a high tangential shrinkage of the ray tissue, because this figure is intermediate to all others. It may therefore be concluded that the rays contribute not only by reducing radial shrinkage but also by increasing tangential shrinkage. It would appear that the terms containing Poisson's ratios in equations 13, 14, and 16 cannot safely be neglected, because they lend themselves to a ready explanation of the non-linearity of the relationships between tangential shrinkage and the proportion of ray tissue in earlywood or latewood.

Equation 13 was used to obtain a curve that might fit the tangential shrinkage data of the earlywood. Because of the complexity of the equation, no attempt was made to approach the fitting on a statistical basis. The shrinkage values of the ray tissue are known, as is the ratio of the modulus of elasticity values (at 6 percent moisture content, Tables 1 and 2). For the transverse Poisson's ratio of the earlywood and latewood prosenchyma the value of 0.92 was assumed, which corresponds to the theoretical value calculated by Price for a hollow, thin-walled cylinder (15). Poisson's ratio of the ray tissue for the tangential strain due to radial strain was assumed to be 0.50. This figure was taken from Hearmon's table (5), and corresponds to an observed value of another species of oak for tangential strain due to longitudinal strain. This left one unknown constant in the equation— the transverse shrinkage of the earlywood prosenchyma. To obtain this, the mean tangential shrinkage of the earlywood specimens without a broad ray and their mean proportion of ray tissue was substituted into equation 13 along with the unknown and assumed constants, and the transverse shrinkage of the earlywood prosenchyma was calculated. This was found to be 4.2 percent.

The points of a curve that expresses the tangential shrinkage of the earlywood as a function of the proportion of ray tissue could then be calculated. This curve is shown in Fig. 11. It may be seen that the curve fully conforms to the trends indicated by the data, although the exact fit is not particularly good. It may therefore be concluded that the general trends of the tangential shrinkage data of the earlywood can be represented by equation 13, but that the data are not sufficient to warrant definite conclusions about the validity of the equation.

The points of the curve that represents the relationship between the radial shrinkage of the earlywood and the proportion of ray tissue, also shown in Fig. 11, were computed from equation 11 by substituting the experimental shrinkage figure of pure ray tissue and the transverse shrinkage figures of the earlywood prosenchyma calculated from the tangential shrinkage data. In this case the fit is very good, but the scatter and the location of the points are not sufficient to indicate any definite trends of the data as predicted by the equation. The data could have been fitted equally well to a straight line. The data must therefore be considered as inconclusive.

The shrinkage data of the latewood were treated in the same manner, and the curves that relate tangential and radial shrinkage to the proportion of ray tissue shown in Fig. 12 were obtained from equations 14 and 13, respectively. The curve that shows the relationship of the tangential shrinkage of the latewood to the proportion of ray tissue not only reflects the trends shown by the data, but also fits reasonably well. The curve is concave downward, as was found for the earlywood. These data appear to support earlier theoretical considerations. The calculated transverse shrinkage of the latewood was found to be 7.0 percent.

The radial shrinkage data are not so conclusive. As in the case of the earlywood, the data could have been fitted by a straight line. In fact, the calculated curve does not fit very well at the lower end of the ray tissue percentage scale. On the other hand, the restraining influences of the ray tissue on radial shrinkage is considerably more evident from the latewood data than from the earlywood data.

In calculating the points for the curves shown in Figs. 11 and 12, the radial and tangential shrinkage values of earlywood and latewood containing the normal proportion of ray tissue (17

Table 5.—SUMMARY OF MICRO-SHRINKAGE MEASUREMENT DATA

Specimen type	Shrinkage, green to oven-dry, per cent, based on green dimension	
	Radial	Tangential
Ray tissue	2.1	6.6
Earlywood:		
without broad ray	3.2	5.2
with broad ray	3.1	7.8
Latewood:		
without broad ray	4.5	7.9
with broad ray	3.3	9.2

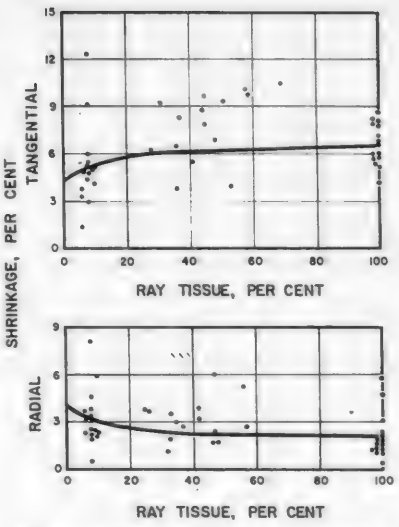


Fig. 11.—Radial and tangential shrinkage of earlywood as a function of the proportion of ray tissue. The curves were calculated (see text), and all points represent individual measurements.

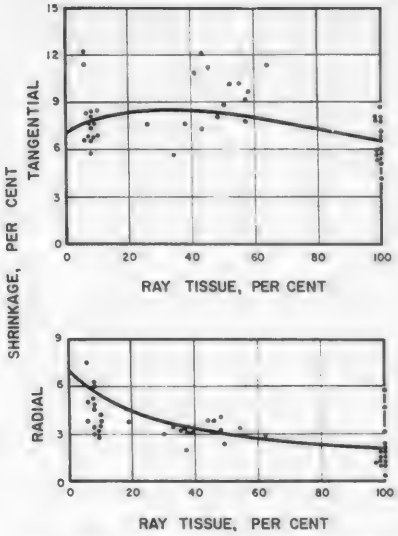


Fig. 12.—Radial and tangential shrinkage of latewood as a function of the proportion of ray tissue. The curves were calculated (see text), and all points represent individual measurements.

percent) were included in the calculations (Table 6). The tangential figures are consistent with the experimental data in Table 5 since, in both the earlywood and the latewood, the calculated figures are intermediate between the experimental figures of specimens with a lower and higher proportion of ray tissue. The calculated radial value of the earlywood is slightly lower than either of the experimental earlywood values, and in the latewood the calculated radial value is slightly higher than the corresponding experimental values. This may indicate that perhaps the shrinkage properties of the ray do depend on the location within the growth increment to some extent.

Table 6.—CALCULATED RADIAL AND TANGENTIAL SHRINKAGE OF EARLYWOOD AND LATEWOOD CONTAINING THE NORMAL PROPORTION OF RAY TISSUE

Component	Radial shrinkage, per cent	Tangential shrinkage, per cent
Earlywood	2.7	5.7
Latewood	4.8	8.4

The aggregate of the micro-shrinkage data is not inconsistent with the theoretical aspects considered above, and the equations given are useful in representing the general trends of the influence of the rays on the radial and tangential shrinkage of earlywood and latewood. The data show clearly that the rays not only decrease the radial shrinkage but also increase the tangential shrinkage, but whether the earlywood prosenchyma and the latewood prosenchyma would have isotropic shrinkage in the transverse plane if the rays could be omitted entirely is not evident. The degree of any possible anistropy of the prosenchyma would appear to be small, however.

Since the radial and tangential shrinkage values of the earlywood and the latewood were found to differ, these would be expected to contribute to the difference between the radial and tangential shrinkage of whole wood. The radial and tangential shrinkage of whole wood was calculated from equations 16 and 15, respectively, by substituting the data of Table 6, the ratio of the modulus of elasticity values (at 6 percent moisture content, Table 1), the average proportion of latewood (0.563), and an assumed Poisson's ratio of 0.3 for radial strain due to tangential strain. The last figure corresponds to an observed value for another species of oak (5). The calculated and experimental (from direct measurement on large specimens) shrinkage values for whole wood are shown in Table 7. The calculated values are slightly higher than the experimental values, but the tangential-to-radial shrinkage ratios are very nearly the same.

In view of the fact that the calculated values are based solely on radial and tangential shrinkage measurements of pure ray tissue and on tangential measurements of specimens that contained only fine rays, plus the results of measurements of properties other than shrinkage and some assumed Poisson's ratio values, the agreement with the experimental shrinkage values is beyond expectations. The data in Table 7 show clearly that differential shrinkage can be explained qualitatively by the theoretical aspects considered above, and expressed quantitatively in terms of the equations presented there. At the same time, it must be pointed out that the agreement between the experimental data and the theoretical aspects, especially with respect to the properties of the earlywood and the latewood, is not sufficient to eliminate the possibility of contributions to differential shrinkage by factors not included in the equations. One of these is the possibility of plastic strains. If these do occur, it is not surprising that the calculated curves shown in Figs. 11 and 12 do not conform precisely to the data.

Table 7.—CALCULATED AND EXPERIMENTAL VALUES OF RADIAL AND TANGENTIAL SHRINKAGE OF WHOLE WOOD

Source	Radial shrinkage, per cent	Tangential shrinkage, per cent	Ratio, T/R
Calculated	3.7	7.7	2.1
Experimental	3.2	7.2	2.3

Further complications arise from the fact that shrinkage does not, as assumed in deriving the equations, occur instantaneously. In the early stages of drying, the ratios of the modulus of elasticity values are not the same as they are at the conclusion of drying, and the plasticity of wood and, presumably, of its components is greater at the higher moisture content percentages. The mechanism that causes differential shrinkage must therefore be considerably more complex than is indicated by the equations given in this study, but in general terms they appear useful in explaining the major part of differential shrinkage.

Conclusions

The following conclusions, applying to the wood of California black oak, can be drawn from the experimental evidence:

1. The difference between radial and tangential modulus of elasticity values can be fully attributed to the high radial modulus of elasticity of the ray tissue. The effect of the rays is sufficiently large to overcome the effect of the difference between the transversely isotropic moduli of elasticity of the earlywood and latewood prosenchyma, which would tend to make the radial modulus of elasticity value lower than the tangential value.

2. The difference between radial and tangential maximum tensile strength values can be fully attributed to the high radial maximum tensile strength of the rays. The effect of the rays again is sufficiently large to overcome earlywood-latewood differences in the prosenchyma, which would tend to make the radial tensile strength lower than the tangential tensile strength.

3. The difference between radial and tangential shrinkage values can be attributed primarily to the low radial shrinkage of the rays. The low radial shrinkage combined with the high radial stiffness of the rays affects the shrinkage of the prosenchyma by decreasing radial shrinkages by restraint and increasing tangential shrinkage as a result of Poisson's effects. The difference between the shrinkage values of the earlywood and the latewood also contributes to differential shrinkage.

4. The agreement between the mathematical relationships and the modulus of elasticity, maximum tensile strength and shrinkage data is generally very good. Notable exceptions were found in the maximum tensile strength data at 6 and 12 percent moisture content which were apparently influenced by residual stresses that resulted from unequal shrinkage of the gross anatomic components.

Gross anatomic structure, particularly the alignment of the rays, was found to be the primary, if not the sole, cause of the transverse anisotropy of the wood properties investigated. For each property, the mechanism could be explained on the same general basis, which suggests that similar considerations may apply to other wood properties. Whether the same results could be obtained on other species remains to be seen, but theoretically there is no reason why the mathematical relationships presented in this paper cannot apply equally well to all species of wood, and some of the results of other investigators also indicate this conclusion. It is to be hoped that a similar approach may be taken in further investigations of the anisotropy of wood properties to promote a more thorough understanding of the complex behavior of wood.

Acknowledgments

The author wishes to express his gratitude to S. B. Preston who suggested the study and under whose guidance the work was planned and completed. The study was carried out at the University of California Forest Products Laboratory, and the author wishes to thank F. E. Dickinson, Director, for making this possible.

Literature Cited

1. Barkas, W. W. 1941. Wood-water relationships. VI. The influence of ray cells on shrinkage of wood. Trans. Faraday Soc. 37:535.
2. Clarke, S. H. 1930. The differential shrinkage of wood. Forestry 4(2):93.
3. Frey-Wyssling, A. 1943. Weitere Untersuchungen ueber die Schwindungsanisotropie des Holzes. Holz als Roh- u. Werkstoff 6(7):197.
4. Frey-Wyssling, A., and F. Stuessi. 1948. Festigkeit und Verformung von Nadelholz quer zur Faser. Schweiz. Ztschr. Forstwesen 99(3):106.
5. Hearmon, R. F. S. 1948. The elasticity of wood and plywood. Dept. Sci. Ind. Res., Forest Prod. Res. Special Rpt. No. 7, London.
6. Keylwerth, R. 1951. Formaenderungen in Holzquerschnitten. Holz als Roh- u. Werkstoff 9(7):253.
7. Kollmann, F. 1956. Untersuchungen ueber die Querzugfestigkeit der Hoelzer. Forstwiss. Cbl. 75(9/10):304.
8. Lindsay, F. W., and L. Chalk. 1954. The influence of rays on the shrinkage of wood. Forestry 27(1):16.
9. McIntosh, D. C. 1955. Shrinkage of red oak and beech. Forest Prod. Jour. 5(5):355.
10. Mariaux, A., and D. Normand. 1954. Anisotropie de retrait transversal du bois. 8th Internat. Botanical Congr., Sect. 13A, Paris.
11. Markwardt, L. J., and T. R. C. Wilson. 1935. Strength and related properties of woods grown in the United States. U. S. Dept. Agriculture Tech. Bull. 479, Washington, D. C.
12. Morschauser, C. R. 1954. The effect of rays on the differential shrinkage of red oak. Jour. Forest Prod. Res. Soc. 4(5): 280.
13. Noerdlinger, H. 1890. Die gewerblichen Eigenschaften der Hoelzer. Verlag der J. G. Cotta'schen Buchhandlung, Stuttgart.
14. Pentoney, R. E. 1953. Mechanisms affecting tangential vs. radial shrinkage. Jour. Forest Prod. Res. Soc. 3(2):27.
15. Price, A. T. 1928. A mathematical discussion on the structure of wood in relation to its elastic properties. Philos. Trans. Royal Soc. London. Series A 228:1–62.
16. Trendelenburg, R. 1939. Ueber Faserstaettigungsfeuchtigkeit, Schwindmass, und Raumdichtezahl wichtiger Holzarten. Holz als Roh- u. Werkstoff 2(1):12.
17. Vintila, E. 1939. Untersuchungen ueber Raumgewicht und Schwindmass von Fruech- und Spaetholz bei Nadelhoelzern. Holz als Roh- u. Werkstoff 2(10):345.
18. Wagner, J. B. 1917. Seasoning of wood. D. Van Nostrand Co., New York.
19. Ylinen, A. 1942. Ueber den Einfluss der Proberkoerpergroesse auf die Biegefestigkeit des Holzes. Holz als Roh- u. Werkstoff 5(9):299.
20. Ylinen, A. 1942. Ueber den Einfluss des Spaetholzanteils und der Rohwichte auf die Festigkeits- und elastichen Eigenschaften des Nadelholzes. Acta Forestalia Fennica 50(5):1.
21. Ylinen, A. 1956. Ueber den Einfluss des Spaetholzanteils und der Rohwichte auf die Elastizitaetsmodulun, die Poissonschen Konstanten und die Schubmoduln bei Holz mit ausgepraegtem Jahrringbau. Technische Hochschule in Finnland, Wissenschaftliche Forschungen Nr 9, Helsinki.

Pulping Sawdust Chips

MADE BY A COARSE-FEED SAW

J. S. Martin

Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Shortness of fibers in sawdust is the major obstacle for its use for pulp. Sawdust chips from a new, coarse-feed saw gave kraft pulp with bursting and tearing strengths of 80 and 85% of those for regular-chip pulp.

THE EXPERIMENTS DESCRIBED in this report were made for the purpose of determining the suitability of specially prepared coarse sawdust fractions for the production of kraft pulps. The pulping characteristics of sawdust chips were compared with those of longer chips of standard size prepared from the same material.

The problem of economic utilization of large volumes of sawdust is of paramount importance to the lumber industry. The short length of the fibers in particles of sawdust has been a major obstacle to its use for making pulp. A 12-tooth saw for the primary breakdown of logs in the production of lumber, recently developed at a commercial sawmill, produces chips with fibers of such length that they may be potentially acceptable for the manufacture of pulp.

The Forest Products Laboratory has undertaken the testing of saws with 12, 18, and 36 teeth in which various tooth forms, including standard stock teeth, are being tried.[3] The pulping trials were made on (1) chips of standard size produced in a chipper, (2) sawdust chips prepared by the 36-tooth saw, and (3) saw chips produced by a prototype of the 12-tooth saw in a commercial sawmill.

[1] Presented at Session XVII, Chemical Utilization, FPRS 13th National Meeting, June 28–July 3, 1959, San Francisco.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Testing of the saws by the Forest Products Laboratory has not progressed to the point that any recommendations regarding their use can be made.

The Author: J. S. Martin received his BS degree in chemical engineering from the University of Maine. He was with the Oxford Paper Co. and York Haven Paper Co. before he joined the FPL in 1929.

Experimental Procedure

Preparation of Chip Samples for Pulping: A southern pine log was sawed into lumber 1½ to 2 inches in thickness by means of a 48-inch saw with 36 teeth. The saw was of the inserted-tooth design, and each tooth had a hollow-ground bit 9/32 inch in width. Sawing a 7-inch face at a carriage speed of approximately 300 feet per minute resulted in an advance of approximately ¼ inch per tooth. The sawdust particles obtained had an average length of ¼ inch in the fiber direction. The sawdust was separated into two fractions by a screen with round openings 3/16 inch in diameter. Forty-five percent of the original sawdust was retained on the screen, and this fraction was designated as sawdust chips. The other fraction was designated as sawdust chip fines. A chipper was used to convert the lumber from the test log into standard chips that averaged ⅝ inch in length and ⅛ inch in thickness.

Also available for the tests was a sample of saw chips produced from other logs by a prototype of the 12-tooth saw blade in a commercial sawmill. Since this sample contained very little fine material, it probably had been partially screened before shipment. The sample received was screened through a 1-inch mesh screen to remove 9 percent of slivers 1½ to 4 inches in length. The screened saw chips used for pulping resembled coarse sawdust, and varied in length in the fiber direction from about 1/16 to ½ inch and averaged about ¼ inch.

Sulfate Pulping: Sulfate pulping digestions were made primarily to produce strong sulfate or kraft-type pulp, but a few bleachable sulfate pulps were also included. For the determination of the yield and strength properties of the pulps, portions of the chips equivalent to 7 pounds of moisture-free wood were cooked in steam-jacketed, cylindrical, tumbling digesters heated indirectly with steam. The moisture in the chips was included in the calculation of the ratio of liquor to wood in

the digester, and water, instead of black liquor, was used to obtain the desired ratio. Pulping conditions are given in Table 1.

Kraft pulps were made from the following forms of material:

(1) Standard-size chips 5/8 inch long in the fiber direction.

(2) Sawdust chips 1/4 inch long in the fiber direction, retained on a 3/16-inch mesh screen.

(3) Saw chips produced commercially that were 1/4 inch long in the fiber direction.

(4) Sawdust chip fines that passed through a 3/16-inch mesh screen, and measured 1/4 inch or less in length.

(5) Equal parts by weight (moisture-free basis) of standard-size chips and sawdust chips.

(6) Equal parts by weight (moisture-free basis) of standard-size chips and sawdust chip fines.

Bleachable sulfate pulps were made from the first three materials described above.

Results and Discussion

Kraft Pulps: Yields of screened pulp (Table 1) fell within a rather narrow range of 44 to 46 percent, and the screening rejects ranged from 0.2 to 2.3 percent. Yields of pulps made from saw chips and from sawdust chips, either alone or in admixture, were essentially the same as the yield from standard chips. Yields obtained from the fines, whether alone or mixed with standard chips, were slightly lower in screened pulp and higher in screening rejects than the other kraft pulps. Values obtained for permanganate number—a test often used as a measure of the chlorine required for bleaching—varied from 27.0 to 29.5, which is within the normal range for kraft pulps. The pulping results indicated that the coarse sawdust types of material were slightly easier to pulp than standard chips, whereas the fines were less readily pulped.

One of the problems in pulping fine material such as sawdust is the difficulty in maintaining uniform liquor circulation and uniform temperature throughout the digester. This problem is encountered even in small autoclaves such as those used in these experiments. The results obtained here are considered satisfactory. The slight increase in screenings for the sawdust chip fines may have been caused by slightly poorer liquor circulation. It is possible, of course, that greater difficulty might be experienced in larger digesters.

The relative bursting strength and tearing strength of the kraft pulps were compared with those of the standard chip pulp as 100 percent. Both the bursting and the tearing strengths decreased as the wood particles became smaller. The Laboratory sawdust chip pulp had 82 percent of the bursting and 88 percent of the tearing strength of pulps produced from conventional chips. Even though the pulp from the commercial saw chips came from different logs and was therefore not directly comparable, it is interesting to note that relative strength values obtained for saw chip pulp were not significantly different from those of the Laboratory sawdust chip pulp. The sawdust chip fines gave the weakest pulp; relative values were 59 percent for bursting strength and 72 percent for tearing strength. For the two mixtures in which 50 percent of the standard chips were used, the pulp made from the sawdust chips was stronger than the one made from the sawdust chip fines, but it was lower in tear than a calculated value based on the tear of pulps made from the individual materials. The strength properties of the sawdust chip pulp and the saw chip pulp in Table 2 indicate that these coarse sawdust pulps are high enough in strength for use alone or in mixture in many kraft papers.

Bleachable Sulfate Pulps: The three bleachable sulfate pulps had ranges of 19 to 23 for permanganate number and 43 to 44 percent for pulp yield. The amounts of screenings were negligible. The Laboratory sawdust chip pulp had the highest permanganate number and would probably not bleach quite so easily as the standard chip or the saw chip pulps. Both the bleachable sulfate and the kraft pulps made from standard-size chips had the same values for bursting and tearing strength. The Laboratory sawdust chip pulp and pulp made from the commercial chips produced with the 12-tooth saw were equal in bursting and tearing factors. These coarse sawdust pulps would be expected to give about 75 percent of the bursting strength and 81 percent of the tearing strength of pulps made from conventional chips.

Table 1.—CONDITIONS[1] AND RESULTS FOR SULFATE PULPING OF SOUTHERN PINE

Form of wood[2]	Active alkali added[3] Percent	Yield[3]		Permanganate number	Relative pulp strength	
		Screened pulp Percent	Screenings Percent		Burst factor Percent	Tear factor Percent
KRAFT PULPS						
Standard-size chip	15.6	45.8	1.1	29.1	100	100
Sawdust chip	15.6	45.2	.7	27.6	82	88
Saw chip (commercial)	15.6	46.0	.2	28.7	75	83
Sawdust chip fines	15.6	44.2	1.4	27.0	59	72
Standard chip and sawdust chip (equal parts)	15.6	45.0	.6	28.4	88	85
Standard chip and sawdust chip fines (equal parts)	15.6	44.1	2.3	29.5	80	87
BLEACHABLE SULFATE PULPS						
Standard-size chip	19.5	43.4	.3	19.7	98	101
Sawdust chip	19.5	44.2	.1	22.9	73	83
Saw chip (commercial)	19.5	42.9	.1	19.0	73	84

[1] Constant digestion conditions: Maximum temperature, 170° C.; temperature increase period, 1.5 hours; duration at maximum temperature, 1.5 hours; sulfidity (based on active alkali), 25.5 percent; liquor-wood ratio, 4.0.
[2] Material prepared at the Forest Products Laboratory unless otherwise noted.
[3] Moisture-free wood basis.
[4] Based on average of values given in Table 2.

Table 2.—STRENGTH PROPERTIES OF SOUTHERN PINE PULPS

Form of wood[1]	Interpolated test beater strength data[2]						
	Beating time Min.	Freeness (Canadian Standard) Ml.	Burst factor	Tear factor	Folding endurance (M.I.T.) Double folds	Breaking length M.	Sheet density Gm. per cc.
KRAFT PULPS							
Standard-size chip	39	450	77	170	950	10,100	0.58
	50	250	87	160	1,040	11,100	.63
Sawdust chip	30	450	65	158	600	8,800	.57
	42	250	70	131	880	10,100	.83
Saw chip (commercial)	35	450	58	141	680	8,600	.59
	46	250	65	132	900	10,000	.64
Sawdust chip fines	23	450	44	123	330	7,600	.58
	31	250	52	114	530	8,500	.64
Standard chip and sawdust chip (equal parts)	31	450	72	160	940	9,700	.60
	46	250	73	121	1,180	9,700	.65
Standard chip and sawdust chip fines (equal parts)	34	450	63	156	590	9,300	.59
	47	250	68	131	790	9,600	.65
BLEACHABLE SULFATE PULPS							
Standard-size chip	35	450	77	188	1,030	10,500	0.61
	50	250	83	146	1,420	11,500	.63
Sawdust chip	28	450	57	145	500	9,500	.60
	39	250	62	129	830	10,100	.67
Saw chip (commercial)	33	450	57	152	920	9,200	.62
	44	250	63	126	1,000	9,900	.66

[1] Material prepared at the Forest Products Laboratory unless otherwise noted.
[2] Test sheets conditioned and tested at 23° C. and 50 percent relative humidty; nominal sheet weight of 72.4 grams per square meter, moisture-free.

Circular Sawing Experiments

ON A RADIAL ARM SAW[1]

C. W. McMillin and J. L. Lubkin
Central Research Laboratory,
American Machine and Foundry Co.,
Stamford, Conn.

Effect of various conditions on net power required to saw certain wood species was determined under various conditions. For flat-sawn hard maple, one formula accurately covered effects of depth of cut, direction of cut, and feed rate.

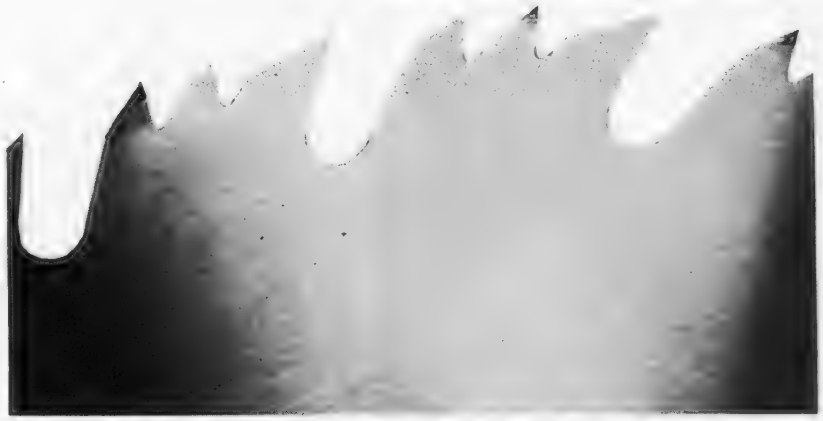


Fig. 4.—Tooth Configuration of 16-in. combination sawblade used in the experiments.

Several years ago, the American Machine and Foundry Co. decided to conduct a comprehensive investigation in the field of cutting processes. The initial emphasis has been on circular sawing because of the product line of the company's DeWalt Division. As a necessary antecedent to theoretical and experimental investigations, an extensive review of the literature on circular sawing was undertaken by Lubkin (1)[2]. Although considerable quantities of information are available on ripsawing, virtually no information was discovered on crosscut or miter sawing of wood. The latter operations are important and are the principal cuts for which radial-arm saws are used.

Accordingly, a broad program of sawing research was established, aimed at objectively defining the basic relationships and principal variables. A program such as this naturally includes consideration of such factors as net cutting power, cutting geometry, surface finish, tool life, and others factors that enter into machinability and equipment design.

The research summarized in this paper is part of this continuing program, which is intended to obtain systematic information on the performance of circular sawblades and circular sawing machines. The effect on net cutting power of such variables as wood species, feed rate, depth of cut, and cutting direction has been measured for a combination-type sawblade. Cutting direction is defined here as the miter cutting angle in the general sense, which includes all directions from the cross to the rip position. Comparative data are also given on "up" and "down" ripsawing.[3] No experimental evaluation of sawed surface quality is included.

Many circular sawing studies presented in the past have failed to report such significant quantities as static and dynamic runout, tooth height variation, and other readily measurable quantities. Such quantities should be systematically measured and reported, so that research results can be evaluated properly by other investigators. The purpose of this research, however, is to obtain data such as might be expected under the comparatively uncontrolled conditions that exist in practice. No effort was made to condition the sawblade to any particular degree of roundness, flatness or sharpness.

Nomenclature

The terminology adopted for use in this study is defined below, in convenient engineering units. Geometrical relations are shown in Fig. 1:

P=net cutting power—hp
f =feed rate—fpm
k=actual kerf width—in.
d=workpiece depth (depth of cut)—in.
R=radius of sawblade—in.
h=distance from axis of sawblade to workpiece surface—in.
f =sawblade protrusion beyond the workpiece—in.
b=arc of sawblade rim engagement in workpiece—in.
W_2=angle at start of sawblade rim engagement[4]—radians
W_1=angle at exit of sawblade rim engagement[4]—radians
A, B, C_1, C_2, C_3, C_4, G, E = constants associated with wood fiber orientation and structure, in various cutting power formulas
c =cutting velocity—fpm
p =tooth pitch of sawblade—in.
Θ=orientation of sawblade plane with respect to the grain. The reference $\Theta = 0°$ is taken as perpendicular to the grain, which is the crosscut direction in straight-grained lumber (Fig. 2). The angle Θ is interchangeably referred to as "the cutting direction." $\Theta = 0°$ and 90° normally correspond to crosscutting and ripsawing, respectively.

Interchangeable terms that refer to the sense of sawblade rotation relative to the feed are tabulated below:

	1	2
(a)	up cutting	down cutting
(b)	normal sawing	climb sawing
(c)	counter sawing	climb sawing
(d)	sawing against the feed	sawing with the feed

Experimental Procedure

Design of the Experiments: Five separate experiments were required to establish the desired relations between net cutting power, feed rate, cutting direction, and depth of cut. Except where noted, all sawing was done as

The Authors: Charles McMillin holds a BS in forestry and wood technology from Purdue, and a MS in wood technology from the U. of Michigan. He is a reesarch engineer for AMF.

James Lubkin holds BS and MS degrees in mechanical engineering and a PhD in applied mechanics from Columbia Univ. He is a senior research engineer at AMF.

[1] Presented at Session III, Wood Machining, FPRS 13th National Meeting, June 28-July 3, 1959, in San Francisco.

[2] Numbers in parentheses refer to the Literature Cited at the end of this report.

[3] See "Nomenclature" section for other terminology commonly used in practice.

[4] These definitions are for "climb sawing" and a clockwise rotation in Fig. 1. For "normal" sawing, the direction of rotation is opposite (counterclockwise) and the subscripts of W_1 and W_2 must be interchanged in the diagram.

normally performed on radial arm saws. That is, all types of miter cuts, including crosscutting, were "climb" cuts, while ripsawing was performed as "counter" sawing. The following experimental designs were adopted:

Experiment No. 1
Species—Hard maple *(Acer saccharum* Marsh.), Douglas-fir *(Pseudotsuga Menziesii* (Mirb.) Franco) and sugar pine *(Pinus lambertian* Dougl.)
Feed rate—10, 20, 40 and 60 feet per minute
Cutting direction (Θ)—0, 45 and 90 degrees

Experiment No. 2
Species—Hard maple *(Acer saccharum* Marsh.)
Feed rate—10, 20 and 40 feet per minute
Depth of cut—⅛, ¼, ½, 1, 1½, 1¾, 2⅞, 3¼ and 5⅛ inches
Cutting direction (Θ)—0 degrees

Experiment No. 3
Species—Hard maple *(Acer saccharum* Marsh.)
Feed rate—20 feet per minute
Depth of cut—¼, ½, 1, 1½, 1¾ inches
Cutting direction (Θ)—0, 45 and 90 degrees

Experiment No. 4
Species—Hard maple *(Acer saccharum* Marsh.)
Feed rate—10, 20 and 40 feet per minute
Cutting direction (Θ)—90 deg., counter and climb sawing

Experiment No. 5
Species—Hard maple *(Acer saccharum* Marsh.)
Feed rate—10, 20 and 40 feet per minute
Cutting direction (Θ)—0, 22.5, 45, 67.5 and 90 (climb sawing) degrees

The following were held constant in all the foregoing experiments:

1. Equilibrium moisture content—sugar pine, 9 percent; Douglas-fir, 9 percent; hard maple, 11 percent.
2. All experimental material was carefully selected from flat-sawn, defect-free, straight-grained lumber.
3. Sawblade protrusion below the workpiece was 1/16-in.
4. Rotational speed was 3600 rpm (3450 rpm at 7.5 hp motor load)
5. Sawblade was a 16-inch, flat-ground, combination-type blade.

Three replications, one each on three boards, were performed for each cutting condition listed in the experimental design. This was found to be adequate in a preliminary experiment to yield a standard deviation of 1.73 per cent of the mean for the worst case. Thus, by ordinary statistical reckoning a band of ± 3.5 percent of the mean should represent a 95 percent confidence coefficient. This is not to imply that less carefully selected and conditioned stock will not give a larger spread.

Experimental Apparatus: A general view of the experimental area is shown in Fig. 3. The machine is basically a standard, industrial, radial-arm saw with a 28-inch crossfeed stroke. The sawblade and yoke assembly are driven across the radial arm by an air cylinder equipped with a hydraulic check valve. Preliminary experimentation revealed that noload feed speeds deviated less than ½ percent from a preset feed rate. The sawblade was driven by a 7.5 hp, 3 phase, 60 cycle, 220/440 volt induction motor. A fixture attached to the saw table facilitated positive clamping of the workpiece. The sawblade was mounted directly on the 1-inch diameter motor arbor by means of the standard 4-inch collar set normally furnished with the machine.

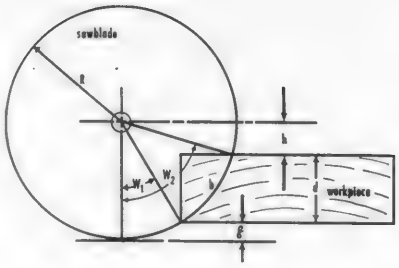


Fig. 1.—Geometrical relations in circular sawing with a radial arm saw. Sawblade is fed from left to right. Clockwise rotation represents climb sawing and counter clockwise rotation corresponds to normal sawing.

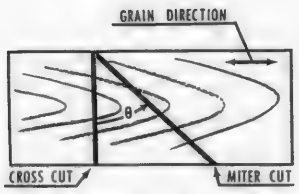


Fig. 2.—Definition of cutting direction (Θ). The angle Θ gives the orientation of the sawblade plane with respect to the grain. As indicated, Θ = 0° is taken to be perpendicular to the grain (cross-cut direction for straight-grained lumber). Rip-sawing corresponds to Θ = 90°.

The average power input to the saw motor was measured with a Sanborn AC Wattmeter preamplifier (Model 150–2300). This is one of several standard plug-in units for the Sanborn oscillographic recorder employed in this study.

Sawblade Used: Fig. 4 is a close-up view of the sawblade used in these experiments. The blade is considered to be of excellent commercial quality, and was used in the as-received condition. No effort was made to condition it to any particular degree of roundness, flatness, or sharpness. Typical data for sawblades made by the same manufacturer indicate that the arbor hole will normally be 0.0015 inch above nominal bore size. This type of blade is hand-filed and shows a tooth height range of 0.005 inch on the scoring (high) teeth. It has a 0.010-inch range on the raker (low) teeth, which are about 0.030 inch below the nominal scoring tooth diameter.

During the course of the experiments, the blade was inspected for gummy deposits on the teeth and gullets, which were then removed with carbon tetrachloride. A preliminary experiment with an identical blade revealed that significant dulling effects are not measurable with the comparatively small amount of material sawed in these studies.

Actually, two different sawblades of the same type were used in these tests. Experiment 1 was conducted with one blade, and the rest of the studies with a second blade of nominally identical specifications. These are as follows:

diameter—16 in.; type—combination grind—flat; thickness—0.097 in.; nominal set—0.025 in. per side; actual kerf—0.16 in.; no. of teeth—72; no. of groups—24; no. of scorers—48; collar diameter—4 in.; front & top bevel angle (scorers)—10°; clearance angle (scorers)—30°; clearance angle (rakers)—20°; hook angle (scorers)—10°; hook angle (rakers)—27°; rakers have no additional bevel angles.

Preparation of Test Material: All experimental material was conditioned for several months in a constant temperature and humidity chamber. This resulted in the equilibrium moisture contents listed in the experimental design. Sufficient test material was then selected from the conditioned stock. Only flat-sawn, defect-free, straight-grained material was used. Two-foot-long test specimens were prepared and suitably randomized, so that each replication of the experiments was made on a different specimen. The experimental material was then surfaced to the required thickness and returned to the conditioning chamber for one week.

Method of Cutting: Before any material was cut, the saw motor was allowed to operate for at least 20 minutes. Experimental material was then removed from the conditioning chamber in small quantities so as to minimize moisture-content changes during cutting. A special fixture was used to assure positive clamping of the workpiece to the saw table. Individual cuts were made 1 inch from the end of the test specimen to avoid the false power readings that may result from cutting too close to a free edge. Moisture content and specific gravity samples were taken during the experiments to detect any substantial variation in these properties.

All ripsawing operations were performed by the air-hydraulic crossfeed

system, which was employed here for precise and convenient control of the feed rate. In this case, the grain of the lumber is oriented parallel to the radial arm (direction of crossfeed travel). Counter ripsawing is an unusual operation on this type of machine. It is accomplished by rotating the yoke assembly 180° from the normal crosscut position. Cross and miter cuts were performed in the normal manner; that is, by rotation of the radial arm assembly about the vertical column.

Method of Analyzing Power Records: Fig. 5 shows a typical oscillographic power recording. Only the power recorded between points A and B, or the portion of the cutting cycle where the sawblade rim is fully engaged in the workpiece, is considered in establishing the power required to make the cut (see also Fig. 1). A microswitch system is used to indicate these points directly on the oscillographic recording. A straight line is then fitted by eye to determine the average power consumed during this portion of the cut. By appling the wattmeter calibration factor to the average pen deflection thus established, the gross input power consumed is obtained.

To obtain the net cutting power for any given run, it is necessary to subtract system idling losses in a suitable manner. The idling losses on the power records cannot be subtracted directly because motor efficiency changes with load. It is therefore best to use a manufacturer's calibration curve. This was done in the present case. When the data were analyzed, appropriate allowance had thus been made for the individual idling losses of the blade-collar combination used, which amounted to 157 watts here. All the results of this report are given in terms of the net cutting power required for the cutting conditions in question.

Results and Discussion

Power versus Feed Rate: Figs. 6–8 show the power versus feed rate relation obtained for 3 species and 3 cutting directions. Ripsawing here was performed by countersawing. These curves appear normal, and agree in shape with previous sawing studies in both wood and metals, where linear relations are commonly found. See, for example, the wood-sawing studies carried out by Endersby (2) at the British Forest Products Research Laboratory. For the sawing of nonferrous metals, see the research performed by Nuss (4) at DeWalt.

As usual, additional power is required to saw material as the feed rate is increased. When all other factors are held constant, the thickness of the chip that the cutting edge or edges must remove is determined by the feed rate. The chip thickness, in turn, basically determines the power required to detach and remove the chip. There are, however, many additional factors such as wood species, grain orientation, moisture content, and machine and sawblade factors, which may or may not have a pronounced effect.

The relative position of the individual species curves for a given cutting direction should be noted. In normal ripsawing and 45° miter cutting, the curves are well separated. In crosscutting, sugar pine and Douglas-fir appear to require approximately equal power for the cutting conditions under consideration.

It is assumed that the lumber used is representative of the species under test. Actual specific gravity measurements show that the maple used was 10 percent less dense than the species average, sugar pine was 10 percent high, and the Douglas-fir was very close. This variation, for small samples, is well within the density range to be expected. Within a species, cutting power would be expected to be approximately proportional to the spe-

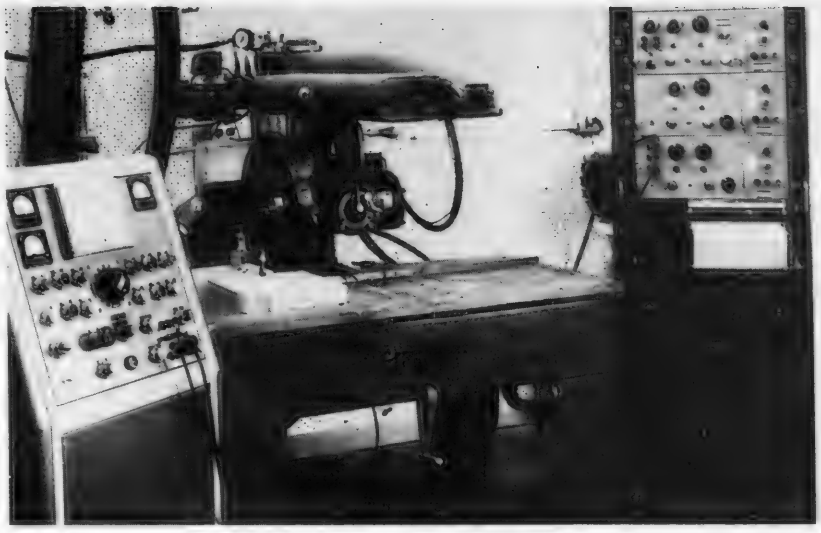


Fig. 3.—General View of Experimental Equipment.

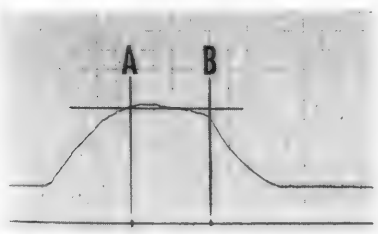


Fig. 5.—Typical motor input power recording. Between points A and B, the sawblade fully engaged in the workpiece.

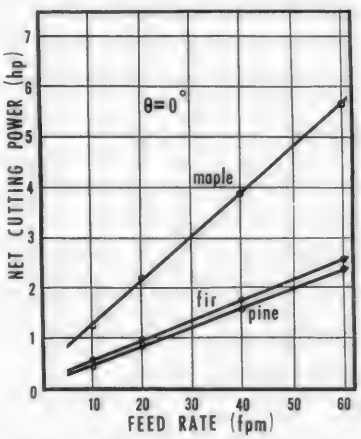


Fig. 6.—Net cutting power versus feed rate when crosscutting three species at 1 5/8 in. depth of cut.

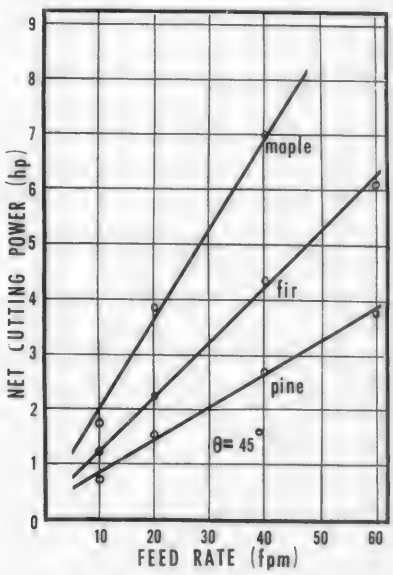


Fig. 7.—Net cutting power versus feed rate when 45° miter sawing three species at 1 5/8 in. depth of cut.

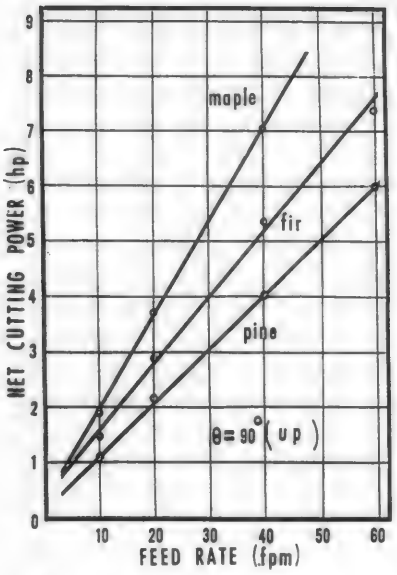


Fig. 8.—Net cutting power versus feed rate when (counter) ripsawing three species at 1⅝ in. depth of cut.

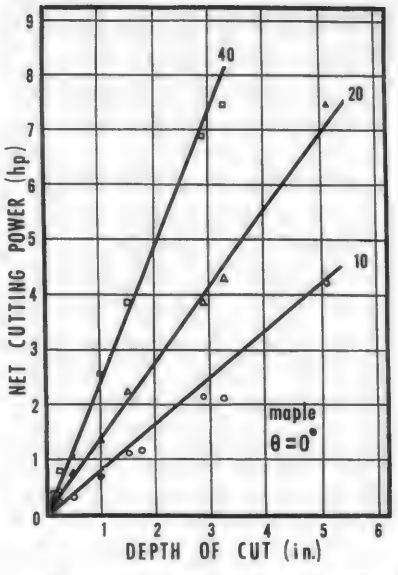


Fig. 9.—Net cutting power versus depth of cut for three feed speeds. Numbers next to curves give feed speed in fpm.

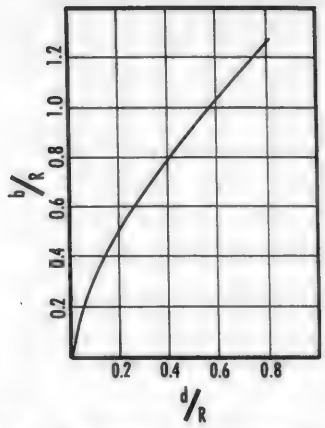


Fig. 10.—Relation of dimensionless arc ratio b/R (angle of saw rim engagement to dimensionless workpiece depth ratio d/R Sawblade operated at 1/16-in. fixed protrusion (f/R = 1/128).

cific gravity of the particular wood sample involved. If adjustments are made to some arbitrary standard of specific gravity (such as a regional or national average), the relative positions of the curves of Figs. 6–8 will change slightly. For this reason, any cutting-power value presented here or elsewhere cannot be taken as absolute without a close statement of specific gravity, and the many other factors that significantly affect the cutting resistance of wood.

No evaluation of the quality of the sawed surface was made in this study. However, visual examination of specimens indicated that, in general, the greater the feed rate, the poorer the quality of the sawed surface. Since increasing the feed rate increases the feed per tooth, it is reasonable that the sawed surface would reflect increased surface roughness.

Power versus Depth of Cut: Fig. 9 shows the relation of net cutting power to depth of cut for three feed speeds, when hard maple is crosscut. A concave-upward tendency is apparent for small depths of cut, particularly at the slower feed speeds. After a certain small depth of cut is reached, a direct proportionality to workpiece thickness may be considered to exist. These results are in agreement with the experiments of Lotte and Keller (5), who also appear to have worked with a small, fixed protrusion of the sawblade through the workpiece.

The present results are not to be compared directly with the many other studies of effects of workpiece thickness. This is because most other tests have been conducted on types of equipment, such as bench or mill saws, where it is normal to keep fixed the distance h between the saw arbor axis and the table or carriage. Thus the experiment is conducted with varying sawblade protrusion as the workpiece thickness is varied, whereas in the present tests and those of Lotte and Keller (5), the sawblade protrusion is held fixed at a small amount. Endersby (2) has given a clear picture of the situation where the table height is held fixed.

It should be pointed out that this entire study has been conducted with carefully selected, flat-sawn lumber. If it is suitably oriented, quarter-sawn lumber may be expected to give slightly different results.

The following formula is given by Harris (6) to determine the power P required for a given set of cutting conditions with a spring-set circular saw of uniform tooth pitch:

$$P = k\,[Abc/2p + Bfd] \quad (1)$$

Here A and B are constants that depend upon wood properties and orientation relative to the sawblade, f is the feed rate, d is the depth of cut (workpiece thickness), and b is the arc length of sawblade rim engagement. Since the cutting velocity c, the tooth pitch[5] p and the kerf width k are constant in this experiment, Eq. (1) may be rewritten with modified constants as:

$$P = C_1 b + C_2 fd \quad (2)$$

The results shown in Fig. 9 are in agreement with Eq. (2), where P is proportional to d in the second term provided b is also proportional to d in the first term. This would constitute analytical support for the form of the experimental curve.

It can be shown, however, that b is not directly proportional to d for small depths of cut. Radial-arm sawing machines are normally used to saw wood with a small, fixed blade protrusion f. This is generally found to be the most efficient cutting position for wood (1, 5), although elsewhere it is found to be the least efficient for sawing metals (4). The arc of sawblade rim engagement can be calculated on the basis of cutting geometry from the following (see Fig. 1):

$$b = R\,(W_2 - W_1) \quad (3)$$

Fig. 10 shows the relation of the dimensionless ratios b/R and d/R for the sawblade in question, operated at a fixed protrusion of 1/16 inch.

Actually, b is not proportional to d. Because of the nature of wood, however, two other factors enter the picture. First of all, the contribution of the first term in Eq. (2) is normally much smaller than that of the second term, at most feed rates of a practical order of magnitude (assuming a reasonably sharp sawblade). On this basis alone it would be reasonable to approximate b by a suitable mean straight line through the origin, for purposes of the present analysis.

Secondly, again because of the nature of wood, parameters such as C_1 and C_2 actually depend upon the grain orientation relative to the cutting edges of the sawblade. In fact, this seems to be the only way to account for previous experimental work, which almost always shows that it is slightly more efficient to ripsaw wood with a small blade protrusion than with a large protrusion. With an argument

[5] Although Eq. (1) is strictly applicable to sawblades with uniform tooth pitch, it is clear in principle that it can readily be extended to accommodate combination-type sawblades.

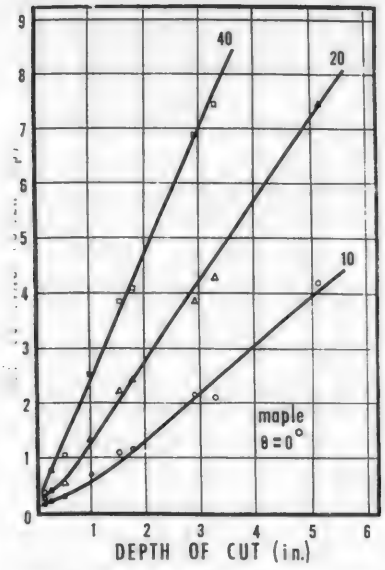


Fig. 11.—Net cutting power versus depth of cut for three feed speeds (test data fitted by straight lines). Numbers next to curves give feed speed in fpm.

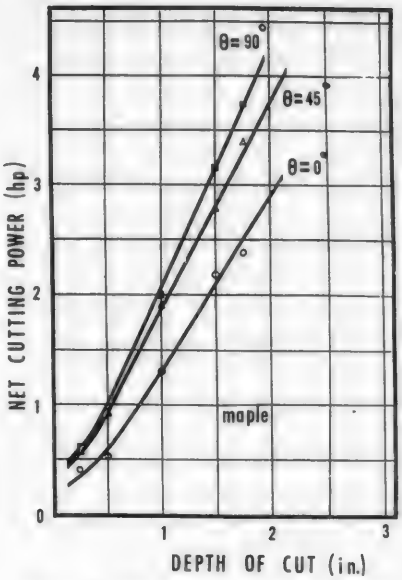


Fig. 12.—Net cutting power versus depth of cut for three cutting directions.

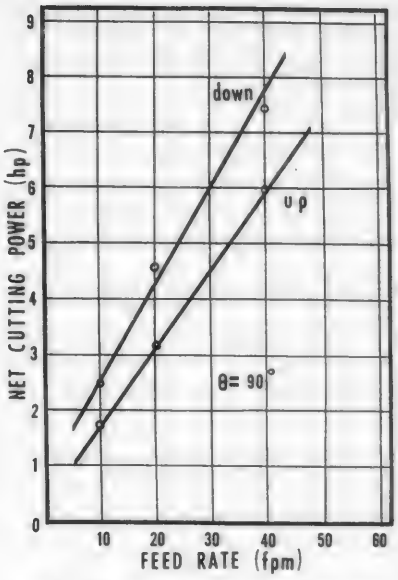


Fig. 13.—Net cutting power versus feed speed for up (normal) and down (climb) ripsawing of 1⅝ in. hard maple.

along the latter lines, it is possible to give a reasonable explanation for the shapes of the experimental curves in Fig. 9. The minor variations involved, however, are more of academic than of practical significance.

It therefore seems sufficient for the present purposes to do the following. In Eq. (2), consider C_1 *and* C_2 to be so altered that it can be written approximately:

$$P = d\,[C_3 + C_4 f] \quad (4)$$

This indicates that net cutting power is a linear function of feed rate, which is adequate to describe the results of most experiments. Also, net power is directly proportional to workpiece depth. This is well supported by the results of Fig. 9, except at very small depths of cut. To show how well the data of Fig. 9 can be represented by straight lines through the origin, the same points are fitted by straight lines in Fig. 11. The fit is seen to be very good.

While Eq. (4) is sufficiently accurate for engineering analysis of the effects of feed rate and depth of cut, it must be remembered that the "constants" C_3 and C_4 actually depend upon wood-fiber orientation relative to the cutting edges. Their values must be obtained by matching the formula in question to suitable experimental results. This is further clarified by the data to be discussed now.

Fig. 12 is a comparison of relation of net cutting power to depth of cut for the rip, 45° miter, and crosscut directions in hard maple. Ripsawing is performed here as up-cutting, while the other operations are performed as climb sawing (also as usual). These curves have been drawn with a slight concave-upward curvature for small depths of cut, which is the trend shown in Fig. 9. If the reasoning employed in re-drawing Fig. 9 to Fig. 11 is considered, however, it can be seen that a formula such as Eq. (4) will also be sufficiently precise for all cutting directions. Suitable constants C_3 and C_4 must, of course, be determined for the cutting direction in question. In other words, the data of Fig. 12 can likewise be fitted quite accurately by straight lines through the origin.

Effect of Climb versus Counter Ripsawing: Examination of Figs. 6–8 reveals that, under certain cutting conditions, 45° miter sawing appears to require as much (or more) power as ripsawing. The following is an explanation of this apparent inconsistency.

Radial-arm saws normally operate in a climb-type cut for cross and miter sawing for all miter angles short of the rip position. Ripping, however, is usually performed by counter sawing. Climb and counter sawing, as may now be seen, required different amounts of power and hence must be carefully distinguished in all discussions of sawing direction.

Fig. 13 is a comparison of the net cutting power required for ripping hard maple by climb and counter sawing. Climb sawing requires substantially more power than does counter sawing. The amount is about 25 per cent for this case. These results are consistent with studies conducted in Sweden and Norway on bench and table saws (3).

The Swedish–Norwegian studies suggest that climb ripsawing is readily practicable if negative hook angles are employed. Cutting powers are then 50 to 70 percent greater than for counter sawing, however, because of the unfavorable (negative) hook. Climb cutting with blades ground with normal positive hook angles is found to be unstable in long cuts because of a tendency to overheat. This is attributed to such factors as 1) a greater mean sawdust movement in the gullet, and 2) less favorable motion of the sawdust while in the gullet of the saw. Both of these factors tend to give more opportunities for the sawdust to escape from the gullet area and increase frictional rubbing. The rubbing action, in turn, generates sufficient heat to produce thermal instability in the blade.

Actual sawdust motion was studied photographically with a special 0.3-microsecond stroboscopic flash camera. The photographs were taken through two transparent plastic plates, which were fixed to the sawblade and rotated with it. Narrow wood specimens were then fed between the plastic plates. Such factors as clearance angle, "shock" loading on tooth entry into the cut, and gullet clogging are also considered as possible causes of overheating, but are discounted on the basis of various theoretical and experimental considerations.

On the basis of the Swedish–Norwegian studies, climb ripsawing with the blade used in the present tests would be expected to show up even less favorably than is indicated by Fig. 13. This is because the present experiments were conducted with very short speci-

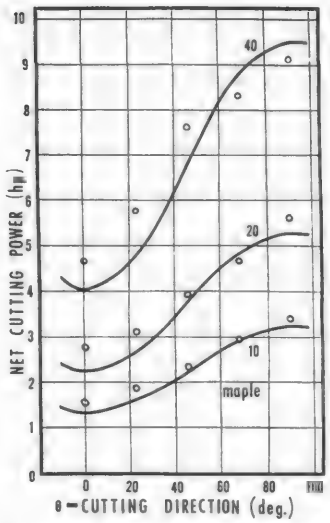


Fig. 14.—Net cutting power versus cutting direction (Θ) for three feed speeds. Numbers next to curves give feed speed in fpm.

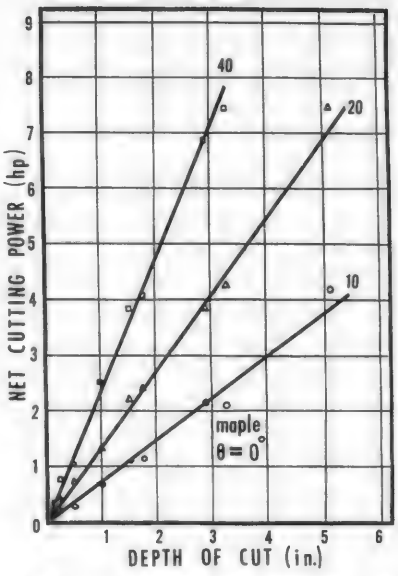


Fig. 15.—Diagram for evaluation of curve-fit: net cutting power versus depth of cut for three feed speeds in fpm. The lines are drawn from Eq. (7). Original test data are also shown.

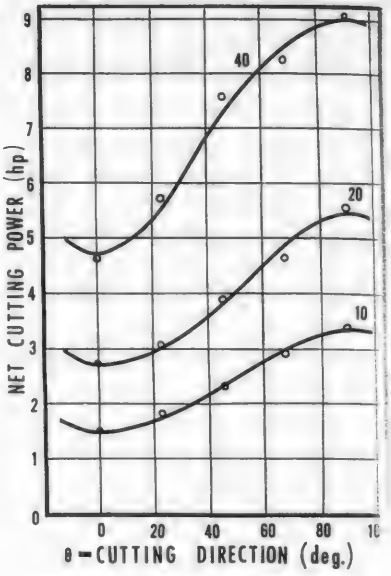


Fig. 16.—Diagram for evaluation of curve-fit: net cutting power versus cutting direction for three feed speeds in fpm. Curves are drawn from Eq. (7). Original test data are also shown.

mens, and heating effects had no chance to become significant.

As the foregoing discussion implies, it is not correct to interpolate between miter and ripsawing in Figs. 7 and 8, since the former is obtained by climb sawing and the latter by counter sawing. Figs. 6 to 8 are perfectly correct, however, for radial-arm saws as normally operated. The question of interpolation between the 45° miter cut and the crosscut positions is treated in much greater detail in the next section.

Cutting Direction: Fig. 14 shows the relation of net cutting power to cutting direction for the blade in question when hard maple is sawn at various feed speeds. In the present case, all cuts (including rip cuts) were performed by climb cutting so that a valid comparison may be made. It follows from Fig. 14 that cutting power in climb sawing can be related to cutting direction by an expression of the form:

$$P = G\,[1 + E \sin^2 \theta] \quad (5)$$

where G and E are constants and θ is the cutting direction (see Fig. 2 and the Nomenclature Section). For example, $\theta = 0°$ is cross-cutting, θ between 0° and 90° is miter cutting, and $\theta = 90°$ is (climb) ripsawing. Further use will be made of this relation in the next setcion.

Notice that the curves drawn in Fig. 14, as well as the formula of Eq. (5), imply that cutting power is a symmetrical function of θ at $\theta = 0°$ and $\theta = 90°$. For straight-grained lumber, this must clearly be the case. That is, a miter cut at $\theta = 20°$ must require the same power as a miter cut at $\theta = -20°$. This implies that the power curve is symmetrical about the $\theta = 0°$ position. The same must also be true of miter cuts near the climb rip position, $\theta = 90°$. That is, a cut at $\theta = 100°$ should require the same power as at $\theta = 80°$.

Derivation of General Power Formula: As previously stated, the power required for a given set of cutting conditions for a spring-set circular saw, can be approximated by Eq. (1). This can be rewritten to Eq. (2) with modified constants when k, c and p are fixed. Although d is not strictly proportional to b for small depths of cut, it has been shown that it is sufficiently accurate to rewrite Eq. (2) as Eq. (4). It has also been shown that power is related to cutting direction in the manner expressed by Eq. (5). It is the purpose of the present section to show that all of these relations can be combined into a single formula with good accuracy.

For a given depth of cut d, feed rate f, and cutting direction θ, it is assumed that net power P is given by the formula

$$P = d\,[C_3 + C_4 f]\,[1 + E \sin^2 \theta] \quad (6)$$

in which C_3, C_4 and E are constants to be determined empirically. The constant G of Eq. (5) has been absorbed into C_3 and C_4 to avoid introducing additional parameters.

By standard methods of curve fitting, it is straightforward to fit actual test data to Eq. (6). The experimental points must be chosen in attempting to match the formula to the actual behavior of the saw. To show what can be done in this respect, the constants C_3, C_4 and E have been evaluated by using all the test results of Figs. 14 and 11 (or its equivalent Fig. 9), simultaneously. The result is

$$P = d\,[0.284 + 0.0548\,f] \times [1 + 1.343 \sin^2 \theta] \quad (7)$$

On the basis of this formula, Figs. 15 and 16 were drawn, which correspond to Figs. 11 and 14, respectively. The merit of the curve-fit formula can be judged by comparing the positions of the calculated (solid) curves with respect to the original experimental points, which are also shown. When the wide range of feed rates, cutting directions, and depths of cut involved are considered, it can be seen that the formula works rather well.

The curve-fit of Eq. (7) has been obtained by the well-known "method of least squares," a systematic procedure for data analysis in this type of problem. This procedure is indiscriminate in the sense that it gives equal weight to all experimental data. The saw engineer may, in some cases, be willing to sacrifice accuracy at the lower feed rate and depth of cut end of the scale (see Fig. 11), where net cutting power is well below machine capacity and a somewhat larger error can be tolerated. Under these circumstances, it should be possible to improve the fit of the data to the formula elsewhere (see, for example, the left region of Fig. 16). For practical purposes, the present formula is sufficiently precise to be useful. In fitting many variables to a single formula,

one commonly expects some sacrifice in the quality of fit.

To obtain ripsawing powers in counter sawing, values of P calculated from Eq. (7) should be reduced by about 20 percent.

Equation (7) should not be applied to the sawing of quarter-sawn (radial-sawn) lumber, to species other than hard maple, to sawblades other than the 16-inch combination blade tested, and so on. Additional tests will have to be run to determine the constants C_3, C_4 and E for these situations. This can be done for a variety of species and sawblades, with a minimum of experimentation, by proper use of statistical techniques.

Acknowledgement

Appreciation is extend to Dr. Joseph Bryan, Central Research Laboratory, for aid in the statistical design and the analysis for fitting the experimental data to the general power formula, and to Mr. O. H. Nuss, American Machine and Foundry Company, for helpful suggestions and criticisms.

Literature Cited

1. Lubkin, J. L. 1957. A statuts report on research in the circular sawing of wood, Vol. 1. Tech. Report No. CRL–T–12, Central Research Laboratory, American Machine & Foundry Co., Stamford, Conn.
2. Endersby, H. J. 1953. The performance of circular plate ripsaws. Forest Products Research Bull. 27, Dept. of Scientific and Industrial Research, Great Britain.
3. Englesson, T., G. Hvamb, and B. Thunell. 1954. Nägra Resulat Från Undersökningar över Med- Och Motsäging (Counter and climb ripsawing investigations). Svenska Träforskningsinstitutet, Träteknik, Meddelande 53B, Stockholm, Sweden.
4. Nuss, O. H. 1958. High speed circular sawing of aluminum alloys. ASTE Paper No. 71, Vol. 58.
5. Lotte, M., and R. Keller. 1949. La scie circulaire (The circular saw). Brochure Technique No. 8, Institut National du Bois, Paris.
6. Harris, P. 1954. Mechanics of sawing: Band and circular saws. Forest Products Research Bull. No. 30, Dept. of Scientific and Industrial Research, Great Britain.

NEW METHOD OF CALCULATING

Internal Stresses in Wood[1]

R. L. Youngs and C. B. Norris

Forest Products Laboratory, Forest Service[2]
U. S. Department of Agriculture

A method for calculating the perpendicular-to-grain normal and shear stresses at any point in the cross section of a board is described. The method can be applied to boards at any stage of drying. Measurements are made on thin slices cut parallel to the face of the board.

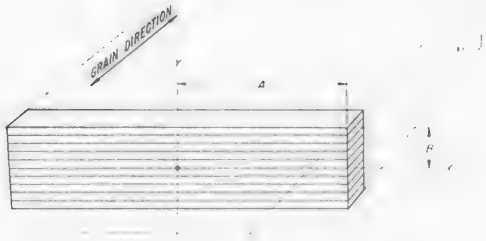


Fig. 1.—Location of strain analysis section and slices cut for recovery measurement with respect to drying board and coordinate axes.

As wood dries, it is strained by a complex pattern of internal stresses that develop as a result of restraints characteristic of normal shrinkage. Such stresses are found in all lumber during normal drying, and are responsible for most of the defects associated with the drying process.

Such stresses have been known and recognized for many years. Considerable progress has been made in interpreting data on drying stresses and applying such information to the improvement of wood drying procedures (2,5).[3] Yet there remains a real need for a thorough fundamental understanding of the drying behavior of wood and the stresses that lead to drying defects.

In recent years, investigations of the stress behavior and perpendicular-to-grain mechanical properties of drying wood have laid the groundwork for a more fundamental approach to the problem of improved wood drying. Effective use of such data, however, requires a method of evaluating drying stresses at any point on the cross section of a drying board. Such a method has not been available up to this time.

A method for calculating the perpendicular-to-grain stresses associated with the drying process, and an illustration of the application of the method to one condition of wood drying, are presented in Forest Products Laboratory Report No. 2133 (6). That report presents all of the mathematics related to the derivation of the method. This paper summarizes the development of the method and indicates the equations required for its application, together with an illustration of such application.

The Authors: Robert Youngs, technologist at the FPL, holds a BS from New York State College of Forestry, a MS from the U. of Michigan, and a PhD from Yale. He was the 1957 Wood Award winner.

Charles Norris, engineer at the FPL, holds a BS in mechanical engineering from the University of Wisconsin. Norris returned to the Lab in 1942 after 20 years with private industry.

[1] Presented at Session VIII, Wood Drying, FPRS 13th National Meeting, June 28–July 3, 1959, San Francisco.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

Method

The "slicing" technique of drying-strain analysis, as employed by McMillen (3,4) in his investigations of the development of drying stresses in red oak, consists of cutting a cross section 1 inch along the grain from a drying board, slicing the section into several (usually 10) slices parallel to the broad faces of the board as shown in Fig. 1, and measuring the change in length of each slice as it is cut free. An increase in length indicates release from a compressive stress; a decrease in length indicates release from a tensile stress.

The stresses developed in wood as it dries are not, however, pure tension or pure compression in any one slice. Neither are stresses uniform along the length of any slice. Rather, stresses are developed in gradient form and vary continuously from a surface of the drying board to the center of the board. The strain indicated in the recovery of any slice, therefore, represents a response to the integral of all stresses that exist in the slice just before it is cut free. Any method for accurate estimation of stresses perpendicular to the grain in a drying board should then provide for calculation of stresses at any point of the the cross section, and should not be confined to determination of the average stress indicated by the recovery of a slice. This is especially important in determining stresses in a board early in drying when tensile stress at the surface may be much greater than that indicated by the outside slice as a whole because of a very steep stress gradient in the outer portion of the wood.

The method now developed makes use of data on strain recovery by the "slicing" technique, such as those reported by McMillen (3,4), and data on perpendicular-to-grain elastic properties of matched wood specimens, such as those presented by Youngs (7,8). Since the instantaneous recovery of such slices as they are cut free is an elastic phenomenon, knowledge of elastic properties under comparable conditions of temperature, moisture content, and growth-ring orientation can be used to interpret strain data in terms of stress.

If it is assumed that perpendicular-to-grain stresses developed in drying are very great with respect to parallel-to-grain stresses, the analysis of drying stresses can be treated as a two-dimensional problem. This assumption is justified in dealing with normal straight-grained wood, since the longitudinal shrinkage of such material can be considered to be negligible as compared with shrinkage in either the tangential or radial direction. Thus, with reference to the axes shown in Fig. 1, analysis can be carried out in terms of the normal stress in the x direction (across the width of the board), the normal stress in the y direction (across the thickness of the board), and the shear stress associated with these directions.

The usual method of solving two-dimensional problems of this type is by introducing a function of x and y called a stress function that satisfies the conditions of the problem. The internal stresses in the drying board can be expressed in terms of a stress function, ϕ, such that

$$\sigma_x = \frac{\partial^2\phi}{\partial y^2}, \sigma_y = \frac{\partial^2\phi}{\partial x^2}, \sigma_{xy} = -\frac{\partial^2\phi}{\partial x \partial y} \qquad (1)$$

where σ_x and σ_y are the normal stresses in the x and y directions, and σ_{xy} is the shear stress associated with these directions. A suitable stress function is:

$$\phi = [1 - (x/a)^2]^2 [1 - (y/b)^2]^2 \sum_m \sum_n A_{mn} (x/a)^m (y/b)^n \qquad (2)$$

where a represents the distance from the center of the cross section to an edge and b the distance to the board face, as shown in Fig. 1, and m and n are even positive integers because of the assumed symmetry of stresses around the center of the cross section.

The strain recovery measured in the slicing technique represents instantaneously recoverable, or elastic, strain. The change in length of each slice as it is cut free is given by:

$$F_y = \int_{-a}^{+a} \frac{1}{E_x}\left[\frac{\partial^2\phi}{\partial x^2} \mu_{xy} - \frac{\partial^2\phi}{\partial y^2}\right] dx \qquad (3)$$

where F_y represents change in length (inches), E_x represents the modulus of elasticity in the x direction, and μ_{xy} represent Poisson's ratio. E_x can be introduced either as a constant, if the moisture content and temperature throughout the cross section are essentially uniform, or as a variable to conticity across the cross section (6).

WHAT THIS RESEARCH MEANS

Fundamental improvements in wood drying procedures have been hampered by the lack of a suitable method for evaluating the stresses that develop across the grain in any wood subjected to drying. These stresses are responsible for most drying defects. This paper presents a method for calculating the tensile, compressive, and shearing stresses acting at any point in the cross section of a board at any stage of drying or after drying has been completed. Application of the method described here should lead to better understanding of the mechanics of wood drying behavior and provide a basis for significant improvements in the technique of wood drying.

Equation 3 relates the observed recovery of any slice to the position of the centerline of the slice in the cross section of the board (y). Substitution of suitable values for y yields as many equations as there were slices taken. It is commonly assumed, however, that the stresses are symmetrically distributed about the midpoint of the cross section, and the recovery of each pair of slices equidistant from the midthickness of the board is averaged and applied to one equation to give half as many equations as there have been slices cut. This assumption is not strickly true in drying wood, but is satisfactory for these initial approaches to the problem.

These equations are linear and numerical, except for values of A_{mn}. They may be solved simultaneously to yield form to variation in modulus of elasticity some values of A_{mn}. The remaining values of A_{mn} may be determined by an energy method based on the principle of least work to determine the values of the stress components that produce a minimum strain energy in the system. Once these remaining values of A_{mn} have been calculated, it is possible to determine completely the stress function ϕ. The calculation of normal stresses σ_x and σ_y and the associated shearing stress σ_{xy} at any point on the cross section is then simply a matter of substituting the coordinates x and y of the point in the proper stress equation, as: (see next page)

Application

The technique just described was applied to determine drying stresses perpendicular to the grain in a 2- by 7-inch flat-sawed plank of northern red oak (*Quercus rubra* L.) being dried from the green condition. The section chosen for analysis was cut after 4 days of drying at 80° F. and 85 per cent relative humidity. It was selected for the initial test of this method for several reasons. First, it represented a period early in drying, when the outer surface zone of the wood is under severe tensile stress. Second, the drying temperature was only slightly higher than the room temperature at which the slices were cut, and thus practically eliminated errors caused by temperature change during the slicing operations. Third, the portion of the plank at the surface with a moisture content below the fiber saturation point was so small that no appreciable error would result from assuming a constant value of modulus of elasticity in any one direction throughout the piece, which considerably simplifies the calculations.

It was decided to use in this initial

trial the first five terms of a power series such that the stress function would be expressed as

$$\phi = [1 - (x/a)^2]^2\,[1 - (y/b)^2]^2\,[A_{00} + A_{20}\,(x/a)^2 + A_{02}\,(y/b)^2 + A_{40}\,(x/a)^4 + A_{04}\,(y/b^4]$$

in which x is the distance from center of plank toward the narrow edge, in inches; y is the distance from center of plank toward the broad face, in inches; a is one-half the width of the plank (3.5 inches); b is one-half the thickness of the plank (1.0 inch); and A with subscripts 0, 2, and 4 represents constants with values of m and n corresponding to the appropriate terms of the series.

It was felt that this series would adequately fit the data without excessive calculation. Also, this series could be used conveniently with a constant value of modulus of elasticity, as assumed for the first trial.

An expression for σ_x, the stress in the x direction, was obtained as the second derivative of the above stress function with respect to y. That expression was then integrated with respect to x and multiplied by $1/E_x$ to yield a general expression involving the actual recovery of slices when cut free. A constant value of 64,000 pounds per square inch was assumed for E_x, based on the data of Youngs (7). The following values of y and corresponding values of slice recovery were then substituted to give five simultaneous equations with five unknowns:

Slice	y	Recovery inch
1, 10	0.9	0.0195
2, 9	.7	−.0045
3, 8	.5	−.0055
4, 7	.3	−.0055
5, 6	.1	−.0040

In the above tabulation, a positive value indicates recovery from tension and a negative value indicates recovery from compression. The five equations were solved simultaneously to give:

$A_{02} = 0.3147$
$A_{04} = 0.1060$
$A_{00} = 0.2639 - 1.7500\ A_{20} - 7.1461\ A_{40}$

The constants A_{00}, A_{20}, and A_{40} could not be isolated from the simultaneous equations directly. Therefore, an energy method based on the principle of least work was used to determine those constants from the above relationship between A_{00}, A_{20}, and A_{40}. The constants thus calculated were:

$A_{00} = 0.1677$
$A_{20} = 0.0223$
$A_{40} = 0.0080$

Once these constants had been evaluated, it was simply a matter of substituting them in the expressions for the stresses σ_x, σ_y, and σ_{xy} (equations 4). The values of these stresses at several points on the cross section were then determined by solving the appropriate equation with the values of x and y corresponding to the point under consideration.

Presentation of Data

Fig. 2 through 6 present curves plotted from calculated values of stress, and show the potentialities of the present method of calculation for indicating stress distribution and magnitude at any desired stage of drying. Fig. 2 and 3 show the distribution of stress in the x direction (σ_x) along the y and x axes, respectively, and are two plots of the same data. Fig. 4 shows the distribution of stress in the y direction (σ_y) along the x axis. Fig. 5 shows the distribution of shear stress associated with shear strain in the xy plane (σ_{xy}) along the x axis. Fig. 6 shows the distribution of each of the three types of stress in one quadrant of the cross section of the drying board by means of lines that connect points of equal stress.

Discussion and Implications

The information derived by the technique presented in this report gives a much clearer insight into the stress behavior of drying wood than has heretofore been possible. The stress values themselves are limited in value, since they apply to only one stage of drying of one sample under one set of drying conditions. They do illustrate, however, what can be done by application of the new technique, and should be considered as representative of the possibilities offered by the technique rather than as a detailed stress analysis.

The stresses that have been of primary interest in connection with drying defects in boards and planks are those directed across the width of the board—that is, in the x direction in this analysis. Early in drying, the defect most likely to result from such stresses is surface checking. Fig. 2 and 3 indicate that the highest tensile stress at the surface of the board was about 710 pounds per square inch at the midpoint of the width. If it is assumed that the moisture content of the surface was approximately in equilibrium with the drying atmosphere, or 18 per cent, that portion of the wood would be expected to have a static tensile strength perpendicular to the grain of about 850 pounds per square inch (7). Apparently the stress attained at the surface was nearly sufficient to produce surface checking, especially when it is considered that the stress may be effective for a period of time great enough to produce appreciable weakening because of duration-of-load effects. Similar calculations, based on tests made later after stress reversal, could be used to indicate the likelihood of honeycombing by establishing the location and magnitude of tensile stresses in the interior of the wood.

Figs. 2 and 3 also indicate that the highest compressive stress attained was about 135 pounds per square inch, which is only 20 percent of the tensile strength of green wood at 80° F. (7).

$$\sigma_x = \frac{\partial^2\phi}{\partial y^2} = \frac{1}{b^2}\sum_m\sum_n A_{mn}(x/a)^m[1-(x/a)^2]^2[n(n-1)\,(y/b)^{n-2} - 2(n+2)(n+1)(y/b)^n +$$

$$(n+4)(n+3)(y/b)^{n+2}]$$

$$\sigma_y = \frac{\partial^2\phi}{\partial x^2} = \frac{1}{a^2}\sum_m\sum_n A_{mn}\,(y/b)^n\,[1-(y/b)^2]^2[m(m-1)\,(x/a)^{m-2} - 2(m+2)(m+1)(x/a)^m +$$

$$(m+4)(m+3)(x/a)^{m+2}]$$

$$\sigma_{xy} = -\frac{\partial^2\phi}{\partial x\partial y} = -\frac{1}{ab}\sum_m\sum_n A_m{}^n\,[m(x/a)^{m-1} - 2(m+2)(x/a)^{m+1} + (m+4)(x/a)^{m+3}][n(y/b)^{n-1}$$

$$- 2(n+2)(y/b)^{n+1} + (n+4)(y/b)^{n+3}] \qquad (4)$$

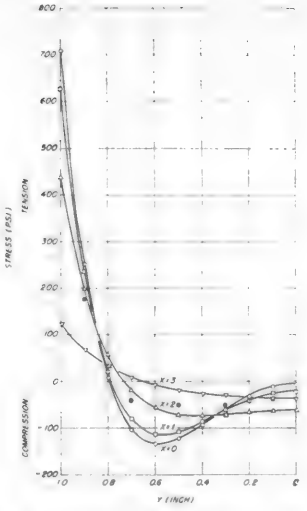


Fig. 2.—Relationship of normal stress in the x direction to distance from the center in the y direction. Values indicated by open symbols were calculated for 4 points in the x axis from the derived formulas, and comparative values indicated by closed symbols were calculated by multiplying recovery strain by modulus of elasticity.

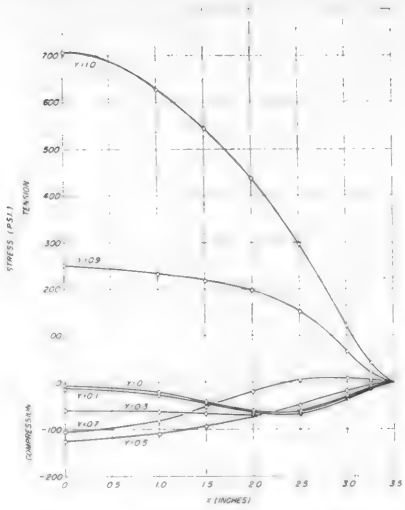


Fig. 3.—Relationship of normal stress in the x direction to distance from the center in the x direction at several points along the y axis. Indicated points were calculated from derived formulas.

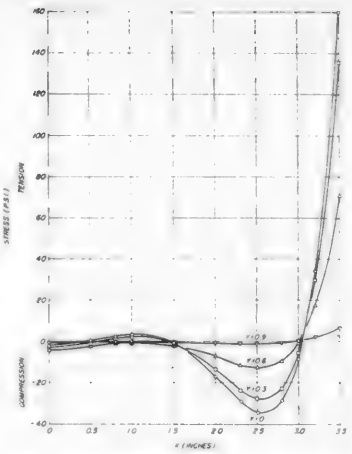


Fig. 4.—Relationship of normal stress in the y direction to distance from the cente in the x direction. Indicated points were calculated from derived formulas.

Such a stress would not be expected to result in any appreciable amount of nonrecoverable creep(set). McMillen's data (4) for the drying run in question agree with this observation by showing development of very little compression set.

Fig. 4 indicates that the maximum tensile stress in the thickness (y) direction is about 160 pounds per square inch, which is slightly less than a quarter of that in the width (x) direction. The ratio of maximum stresses in the two directions is less than would be expected on the basis of the 2:7 ratio of dimensions; this is probably due largely to the fact that shrinkage in the y direction is essentially radial and therefore less, percentagewise, than the tangential shrinkage in the x direction. The maximum compressive stress in the y direction is also about a quarter of that in the x direction. Neither the tensile stress nor the compressive stress indicated in Fig. 4 would be expected to lead to failure or appreciable amounts of set in the thickness direction of the plank.

The role of shear stresses in the development of drying defects has been the subject of some concern, and values of shear strength associated with shear strain in the xy plane of oak have been reported by Kollmann (1) and by Youngs (7). Shear strength values are of no great value, however, until more is known about the location and magnitude of shear stresses developed in drying wood.

Fig. 5 illustrates the type of information on shear stress distribution that is obtainable by the present technique. The maximum shear stress indicated in Fig. 5 is about 45 pounds per square inch, which is only 12 percent of the shear strength value reported by Youngs (7) for the temperature and moisture content conditions associated with the location of maximum shear stress in the specimen under consideration. Apparently the likelihood of shear failure is almost negligible for the stage of drying that is represented in the present analysis. This analysis does not take into account, however, localized shear stress concentrations due to marked differences in shrinkage tendency between adjacent wood elements, such as wood ray cells and longitudinal fibers. Such localized shear stress concentrations could conceivably be greater than indicated in Fig. 5 for the cross section as a whole.

Fig. 6 illustrates how the results of the present analytical technique can be plotted to show distribution of normal stresses in the x and y directions and associated shear stresses at the stage of drying under investigation. Each portion of the figure represents the upper-right-hand quadrant of the cross section, with the assumption that the stresses are distributed symmetrically over the entire cross section of the board. The curves are based on the same data as Figs. 2, 3, 4, and 5, but the plotting in Fig. 6 emphasizes the distribution, rather than the magnitude, of the stresses.

The number of stress values calculated in this first trial of the technique is not sufficient to locate accurately all of the curves shown in Fig. 6. Consequently, the lines are based on the calculated points, but their exact locations are the result of some personal judgment coupled with a consideration of the assumed boundary conditions. It is felt that the lines represent with reasonable accuracy the stress conditions characteristic of the specimen investigated.

Fig. 6A points out the steep tensile stress gradients in the outer slices at the time of cutting, from 0 at the inner boundary of the slice ($y = 0.8$) to about 700 pounds per square inch at the surface, and from about 350 pounds per square inch at midthickness of the slice ($y = 0.9$) in the center of the section to 0 at the end of the slice. Fig. 6A also indicates quite clearly that the maximum compressive stress is not at the center of the cross section, but near the midlength at the boundary between slices 2, 9, and 3, 8 ($y = 0.6$).

Fig. 6B indicates that the normal stresses in the y direction are concentrated near the ends of the center slices and are negligible in the outer slices.

Fig. 6C locates the point of maximum shear stress at about ½ inch from the ends of slices 2, 9 and 3, 8 ($y = 0.6$). This figure also points out that shear stresses are quite small over most of the cross section at the stage of drying under investigation.

As mentioned previously, the principal object in presenting Figs. 2 through 6 is to point out the possibilities offered by the analytical procedure outlined in this report. The advantages of the new technique are readily apparent when the curves are compared with the points in Fig. 2 that were derived by the previous method of merely multiplying the average recovery strain of a pair of slices by the applicable value of modulus of elasticity. The points thus obtained fit into the array of curves, but make possible

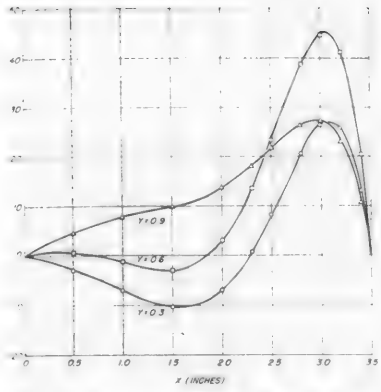


Fig. 5.—Relationship of shear stress associated with shear strain in the *xy* plane to distance from the center in the *x* direction at three levels of *y*. Indicated points were calculated from derived formulas.

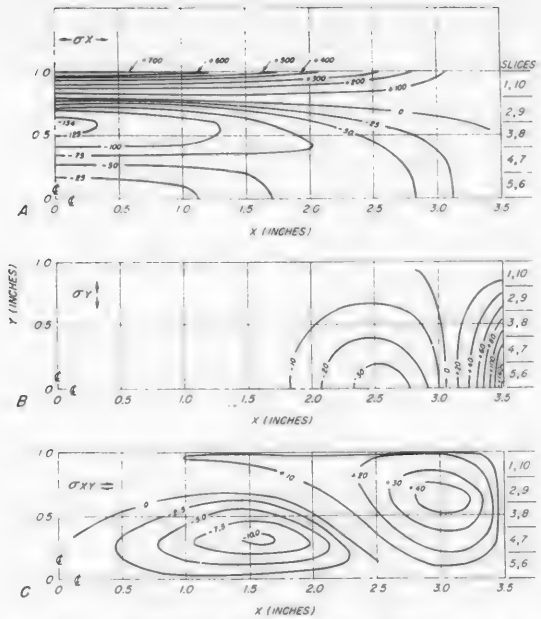


Fig. 6.—Distribution of stress in the x direction (A), in the y direction (B), and associated shear stress (C) indicated by lines that connect points of equal stress.

only a rough estimate of stresses in the *x* direction.

The new analytical procedure makes possible some rather comprehensive analyses of drying stresses, based on data now available on elastic recovery and perpendicular-to-grain mechanical properties of red oak. Similar analysis can be applied to other species and drying conditions as the required data become available. Such application will involve substituting the proper values in equations 4 and carrying out the indicated computations.

The present procedure presents imposing problems in carrying through the computations involved. The advent of the electronic computer, however, has made such problems considerably less formidable than they were a few years ago. It seems likely that future work along this line will be dependent on the use of such a computer to perform the required mathematical operations.

It must be realized, of course, that any such analytical technique, however elegant, is no better than the basic data supplied for analysis. Attention must also be given, therefore, to the techniques used for gathering data on dimensional recovery of slices and on the associated perpendicular-to-grain mechanical properties. If the results of such tests do not reflect accurately the properties and behavior of the drying wood, any subsequent analytical procedure will be limited in its usefulness and may even lead to erroneous conclusions.

The method does not take into account the effects of creep and of prolonged exposure to high temperature on the perpendicular-to-grain mechanical properties of wood; nor does it need to, to yield an accurate evaluation of the stresses. Information on such effects can, and should, be taken into consideration in evaluating the drying behavior of wood with respect to sress patterns indicated by the calculations. Such effects may have an important bearing on drying behavior, both in terms of stress development and in terms of the response of the wood to drying stresses. It is important, therefore, that investigations aimed at providing fundamental information on mechanical properties related to drying include studies of time effects as well as of static strength and elastic properties. Such information, combined with accurate observations of drying behavior of wood under various conditions, should make possible a much more complete understanding of the mechanical aspects of the drying process. Such understanding will probably result in substantial improvements in the practice of wood drying.

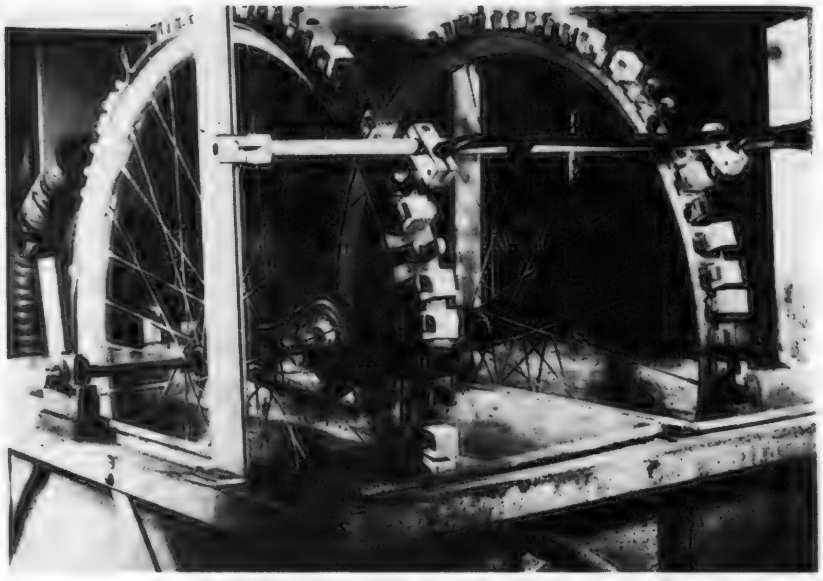
Literature Cited

1. Kollmann, F. 1950. Untersuchungen über die Ursachen von Schäden bei der Trocknung von grünem Eichenholz Zugleich Mitteilung über Festigkeitsprufungen and Holz in hochfrequenten Wechselfeld. Swedish Wood Research Institute, Wood Tech. Dept. Bull. No. 21.
2. McMillen, J. M. 1958. Stresses in wood during drying. U. S. Forest Prod. Lab. Report No. 1652 (rev.).
3. McMillen, J. M. 1955. Drying stresses in red oak. Forest Prod. J. 5(1):71.
4. McMillen, J. M. 1955. Drying stresses in Red Oak: Effect of temperature. Forest Prod. J. 5(4):230.
5. Rietz, R. S. 1950. Accelerating the kiln drying of hardwoods. Southern Lumberman 181(2262):44.
6. Youngs, R. L. and C. B. Norris. 1958. A method of calculating internal stresses in drying wood. U. S. Forest Prod. Lab. Report No. 2133.
7. Youngs, R. L. 1957. The perpendicular-to-grain mechanical properties of red oak as related to temperature, moisture content, and time. U. S. Forest Prod. Lab. Report No. 2079.
8. Youngs, R. L. 1957. Mechanical properties of red oak related to drying. Forest Prod. J. 7(10):315.

Dyes For Preserving Wood[1]

J. W. Weaver, E. B. Jeroski, and I. S. Goldstein
Research Department, Koppers Co. Inc, Verona, Pa.

Southern pine blocks were treated with 41 textile dyes, weathered, and exposed to 6 wood destroying fungi. Triphenylmethane dyes were effective, and one, Ethyl Violet, is an efficient fungistatic compound in wood.



Treated blocks were conditioned on laboratory weathering device

In 1891, Ehrlich demonstrated the antimalarial activity of Methylene Blue, and a few years later discovered that Trypan Red would kill trypanosomes. These disclosures helped lay the foundations of chemotherapy. Since that time, many workers have studied the effects of dyes on micro-organisms, among them Stearn and Stearn (16)[2]. Dion and Lord (7), and Aiquel and Herraro (1) have shown that basic dyes are toxic to *Fusarium culmorum* and to two species of *Aspergilli*. Attempts have been made by Mietzsch (13), Goldacre and Phillips (9), and Fischer (8) to relate the toxicity of these basic dyes to their structures.

Michaelis (10, 11, 12) has attempted to explain the toxicity by showing that basic dyes react irreversibly with nucleic acids. Similar studies have been carried out by Neuberg and Roberts (14), Steiner and Beers (17), and Dimarco and Boretti (6). Basu and Whitaker (3) found that acid and basic dyes were inhibitory to the isolated cellulase of *Myrothecium verrucaria*, and Reese and Mandels (15) inhibited the cellulase of *Trichoderma viride* with Congo Red and Safranin. A U. S. patent issued to Conn (5) disclosed the use of Crystal Violet and Malachite Green for the preservation of cotton fish nets.

A previous publication (18) from this laboratory discussed the toxicity of dyes and related compounds to wood-destroying fungi in nutrient agar plates. Many of these dyes have since been applied to wood, and the efficient decay preventers have been studied extensively via the soil-block test.

The Authors: J. W. Weaver, BS from Loyola U., MS from U. of Detroit, and PhD from Tulane Z. Now senior chemist at Koppers Research Center; E. B. Jeroski, BS from Slippery Rock College, MS from U. of Pittsburgh, now assistant chemist at Koppers; I. S. Goldstein, Manager, Wood Chemistry Group, Koppers Research Center, holds BS from Rensselaer Polytechnic Institute, MS from Illinois Tech., and PhD from Harvard.

[1] A contributed paper, received May 11, 1959.
[2] Numbers in parentheses refer to the Literature Cited at the end of this report.

Materials and Methods

All chemical compounds were used in the purest form commercially available. The dyes are identified by their most common trivial name, but to avoid confusion each name is followed by the new Colour Index Number of the dye from which the molecular structure and other trade names for the dye may be determined by consulting the Colour Index (4).

The wood-destroying fungi used as test organisms were:

Lentinus lepideus	Madison 534
Poria incrassata	Madison 563
Lenzites trabea	Madison 617
Polyporus versicolor	Madison 697
Poria monticola	Madison 698
Coniophora puteana	Madison 515

Southern yellow pine *Pinus* sp.) was cut into ¾ inch cubes, which were treated by the full-cell process in a conventional cylinder, drained, leached for several days in running water, and dried. The small amount of dye deposited in or attached to the wood could not be accurately weighed or determined by any other known means, so the retentions reported were calculated

DYES WHICH WERE INEFFECTIVE AS FUNGISTATS WHEN APPLIED FROM A TWO PERCENT SOLUTION TO SOUTHERN YELLOW PINE SOIL BLOCKS

Name	C.I. No.	Name	C.I. No.
Direct Dyes		**Basic Dyes**	
Chloramine Yellow	19555	Auramine	41000
Congo Red	22120	Para Magenta	42500
Benzo Orange R	22130	Magenta	42510
Congo Corinth G	22145	Victoria Pure Blue B	42595
Sirius Supra Blue FBGL	23155	Spirit Blue	42775
Benzopurpurine 4B	23500	Victoria Blue B	44045
Benzo Blue 3B	23850	Acridine Orange NO	46005
Diamine Sky Blue FF	24410	Phosphine	46045
Sirius Supra Turquoise Blue	74180		
Vat Dyes		**Sulfur Dye**	
Indanthrene Orange RRT	59705	Sulfur Black T Ex.	53185
Indanthrene Brill. Violet RK	63365		
Indigo	73000		
Indigo MLB	73071		

Table 2

DECAY BY PORIA MONTICOLA OF PINE TREATED WITH COPPER-CONTAINING DYES

Name	C.I. No.	Weight Loss, %, After Three Months: Dye Only	Dye Complexed With Copper	Dye Complexed and Weathered
Metachrome Brown B	11335	28.1	34.6	46.5
Alizarine Yellow R	14030	0.2	6.1	29.2
Azo Rubine	14720	19.8	31.4	34.7
Diamine Fast Red F	22310	28.0	30.2	37.0
Diamond Black F	26695	24.6	37.8	39.2
Alizarine VI	58000	12.5	8.9	21.0
Alizarine Red S	58005	20.4	25.6	39.4
Helio Fast Rubine 4BL	58055	20.2	23.2	42.2
Alizarine Supra Blue A	62055	29.6	30.7	45.3
Alizarine Saphirol B	63010	30.4	33.0	40.6
Alizarine Blue Black B	63615	21.9	30.1	34.1

from the concentration of the treating solution and the weight of solution retained.

Before exposure to the test organisms, some of the treated blocks were "weathered" for one month on a laboratory device, which submerged them in running water for 20 minutes of a one hour cycle, and exposed them to ultraviolet radiation while they were being dried in a stream of air for the remainder of the cycle. The blocks, with suitable controls, were then exposed to the test organism for three months in the conventional soil-block test (2).

Results and Discussion

Table 1 lists the dyes that were found to be ineffective when applied to the soil blocks from a 2 percent solution and tested with *Lentinus lepideus, Lenzites trabea,* and *Poria monticola.*

Direct dyes are those which, by virtue of their structure, will adsorb on cellulose from aqueous solutions and form strong hydrogen bonds. Vat dyes are deposited from aqueous solutions of their reduced colorless ("leuco") form by conversion to the insoluble, oxidized, colored form. Although atmospheric oxygen is sufficient to precipitate some of the vat dyes used, all were after-treated with 2 percent aqueous hydrogen peroxide to insure complete conversion to the colored form. The sulfur dye is similarly deposited by oxidation of the solubilized dye. Basic dyes are those in which the complex, colored part of the molecule is cationic, or positively charged. These dyes are water-soluble and react to some extent with acid groups in the wood, and become more-or-less permanently attached.

Another group of dyes tested and found to be ineffective are classed as "mordant" dyes. These days, listed in Table 2, are all sulfonated aromatic compounds containing phenol and quinone groups that can form complexes with heavy metals. Three pine cubes were impregnated with a 2 percent aqueous solution of each of the mordant dyes and dried. Two of these were after-treated with cupric acetate, leached, and dried. One of these copper-treated blocks was then weathered for one month. All of the blocks were then exposed to the copper-tolerant organism *Poria Monticola.* The weight losses observed after three months are given in the table. In no case was there a significant improvement in the fungistatic effect of the dye brought about by the copper after-treatment. In every case, weathering made the treated block more susceptible to attack by the fungus. Alizarine Yellow R was the only dye that inhibited the attack, but this inhibition was destroyed by weathering.

The only effective group of dyes encountered in this study was the "triphenylmethane" type of basic dyes. Results obtained with eight dyes of this type are given in Table 3. Pine soil blocks were treated with a 2 percent aqueous solution of the dye and weathered for one month on the device described above before being exposed in duplicate for three months to the six test fungi. The losses in weight caused by the organisms are listed in the table, together with the average diameter of a four-week growth on a nutrient agar plate that contained 100 ppm (0.01 percent) of the dye (18).

Of the 48 comparisons, the two methods agree in 32 and disagree in 16 cases. In these 16 disagreements, 5 cases involve attack of treated blocks with no growth on the agar plates and 11 cases involve no attack of treated blocks with good growth of agar plates.

The two methods agree in all 8 comparisons with *Lentinus lepideus,* in 7 with *Poria monticola,* and in 6 with *Lenzites trabea.*

When judged by the growth on nutrient agar plates, the most effective dyes are Malachite Green, Setoglaucine, and Brilliant Green, but with the soil-block method the most effective dye appears to be Ethyl Violet, which prevents attack by all six test organsims in the method used in this study.

The obvious differences in the results of the two test methods may be explained in several ways. Where the soil blocks are protected by a dye that was not toxic in the agar plate, it may be assumed that the dye resisted leaching and weathering, and the amount that remained in the block was much higher than the 100 ppm in the agar plate. In other cases, a dye that was toxic in the agar plate might have been easily destroyed by weathering and did not protect the wood block from attack. Finally, the agar plates contain maltose as the principal nutrient, while the wood is attacked for its cellulose content. The utilization of these substrates involves entirely different enzymes, and some of the dyes may have been sufficiently specific to inhibit only one of the metabolic systems.

From a practical point of view, some of these dyes might prove useful for the prevention of decay of wood, so the four successful dyes were studied more exhaustively. Malachite Green, Setoglaucine, Brilliant Green, and Ethyl Violet were each used in concentrations of 0.5, 1.0, 1.5 and 2.0 percent to impregnate 20 soil blocks in groups of 5. The treated blocks were individually weighed before they were dried, and dye retentions were calculated from the solution retentions and the known concentrations. The blocks were weathered and exposed to *Lenzites trabea* for three months. The 20 blocks treated with Malachite Green had original dye retentions that varied from 0.5 to 2.3 percent and weight losses from 17 to 33 percent, with no apparent trend in the relationship. Similarly, the blocks impregnated with Setaglaucine had retentions from 0.4 to 2.6 percent and weight losses from 16 to 33 percent with no visible relationship. With the other two dyes, however, fungistatic thresholds were apparent. The weight losses observed with these dyed blocks are shown in

Closeup of blocks on weathering device. Note color variation.

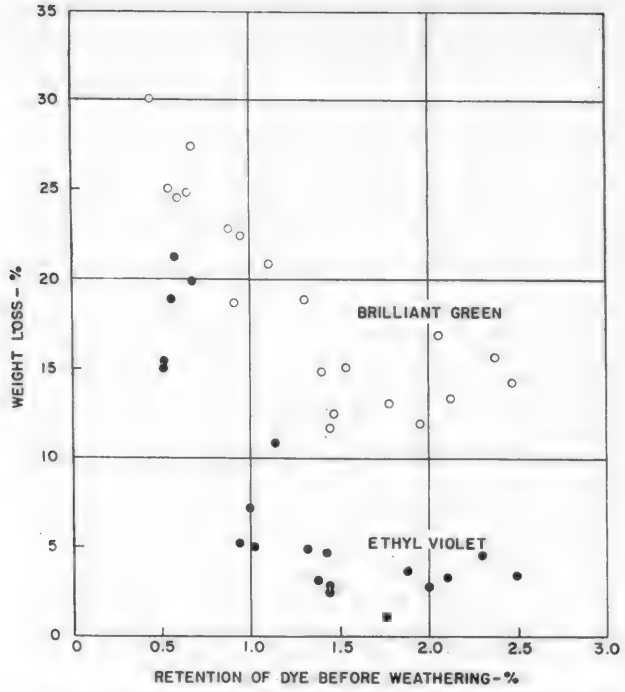


Fig. 1.—Relationship between the retention of Brilliant Green and Ethyl Violet in southern yellow pine soil blocks and the weight lost after three months' exposure to Lenzites trabea.

Fig. 1 with both apparent thresholds at about 1.5 percent dye retention. The leveling off for Brilliant Green at about 14 percent weight loss is interesting, but this dye certainly does not prevent decay by the test organism.

The Ethyl Violet treatment lowers the weight losses to about 3 percent, however, with dye retentions in excess of 1.5 percent. This 3 percent loss in weight can be attributed to losses inherent in the method, and is not considered significant. Thus Ethyl Violet may be considered to be an efficient fungistatic compound in wood.

No attempt has been made to explain the differences in results obtained with these closely related dyes, but it is likley that other related compounds, colored or not, may also prove to be effective fungistats.

Literature Cited

1. Aiquel, F., and F. J. Herraro. 1948. The action of dyes on the development of *Aspergillus niger* and *Aspergillus flavus*. Arch. farm. y bioquim. Tucuman. 4:149. In Chem. Abstracts 47: 10064 (1953).
2. ASTM. 1956. ASTM Standards, 1956 Supplement, part 4, p. 142, Tentative Method DI413–56T, Philadelphia, Pa.
3. Basu, S. N., and D. R. Whitaker. 1953. Inhibition and stimulation of the cellulase of *Myrothecium verrucaria*. Arch. Biochem. Biophys. 42:12.
4. Colour Index. 1956. Second Edition. Society of Dyers and Colorists and the Amer. Assoc. of Textile Chemists and Colorists.
5. Conn, W. T. 1935. Preservation of cellulose materials. U.S. Patent 2,018,-659.
6. DiMarco, A. and G. Boretti. 1950. On the complexes formed by streptomycin and basic dyes with ribonucleic acid. Interference of salts. Enzymologia 14:141.
7. Dion, W. M., and K. A. Lord. 1944. A comparison of the toxicity of certain dyestuffs to the conidia of *Fusarium culmorum*. Ann. Appl. Biol. 31:221.
8. Fischer, E. 1957. Relation between chemical structure and bacteriostatic action in di- and triphenlymethane dyes Arzneimittel-Forsch. 7:192. In Chem. Abstracts 51:9942, 13069.
9. Goldacre, R. J., and J. N. Phillips. 1949. The ionization of basic triphenylmethane dyes. J. Chem. Soc. 1949, 1724.
10. Michaelis, L. and S. Granick. 1945. Metachromasy of basic dyestuffs. J. Am. Chem. Soc. 67:1212.
11. Michaelis, L. 1947. The nature of the interaction of nucleic acids and nuclei with basic dyestuffs. Cold Spring Harbor Symposia on Quant. Biol. 12:131.
12. Michaelis, L. 1950. Reversible polymerization and molecular aggregation. J. Phys. Colloid. Chem. 54:1.
13. Mietzsch, F. 19936. Behavior of certain dyes and chemotherapeutics on the introduction of neutral substituents. Med. u. Chem. Abhandl. Med.-chem. Forschungsstatter I. G. Farben. 3:348. In Chem. Abstracts 31:5865 (1957).
14. Neuberg, C., and I. S. Roberts. 1949. Remarkable properties of nucleic acids and nucleotides. Arch. Biochem. 20:185.
15. Reese, E. T. and Mary, Mandels. 1957. Chemical inhibition of cellulases and beta-glucosidases. Microbiology Series No. 17, Quartermaster Research and Development Center, Natick, Mass.
16. Stearn, A .E., and E. W. Stearn. 1924. The chemical mechanism of bacterial behavior III. The problem of bacteriostasis. J. Bact. 9:491.
17. Steiner, R. F., and R. F. Beers, Jr. 1958. Spectral changes accompanying binding of Acridine Orange by polyadenylic acid. Science 127:335.
18. Weaver, J. W., E. B. Jeroski, and I. S. Goldstein. 1959. Toxicity of dyes and related compounds to wood-destroying fungi. Appl. Microbiol. 7. in press.

Table 3

BIOLOGICAL RESISTANCE OF WOOD TREATED WITH TRIPHENYLMETHANE DYES

Dye	C.I. No.	Lentinus lepideus Wt. loss (1)	Lentinus lepideus Agar growth (2)	Poria incrassata Wt. loss	Poria incrassata Agar growth	Lenzites trabea Wt. loss	Lenzites trabea Agar growth	Polyporus vericolor Wt. loss	Polyporus vericolor Agar growth	Poria monticola Wt. loss	Poria monticola Agar growth	Coniophora puteana Wt. loss	Coniophora puteana Agar growth
None	-	33.7	9	19.0	9	30.2	9	23.3	9	31.2	9	37.5	9
Malachite Green	42000	3.4	0	7.2	0	24.6	0	1.2	0	1.5	0	1.1	5
Setoglaucine	42025	4.8	0	28.9	0	28.8	0	1.7	0	11.5	0	5.9	2
Brilliant Green	42040	1.4	0	24.2	0	8.0	0	6.5	7	0.5	0	1.1	2
Methyl Violet B	42535	0.9	2	25.1	9	23.3	9	2.8	9	5.1	6	13.7	9
Benzyl Violet	42536	1.1	2	34.8	9	26.2	6	7.7	9	0	2	2.4	9
Crystal Violet	42555	0.4	0	20.5	9	29.5	5	2.2	9	6.7	7	1.8	9
Ethyl Violet	42600	0.6	0	3.0	7	3.6	2	1.7	6	0.9	4	0.4	7
Spirit Blue	42775	11.0	8	41.9	0	35.0	9	16.2	9	19.8	9	16.5	8

(1) Weight loss, %, of weathered soil blocks treated with 2% aqueous solutions of the dye.
(2) Diameter in cm. of four week growth (9 = max.) on nutrient agar plate containing 100 p.p.m. dye.

EFFECT OF POLYETHYLENE GLYCOL ON

The Dimensional Stability of Wood

A. J. STAMM [1]
Forest Products Laboratory[2], Forest Service, U. S. Department of Agriculture

Polyethylene glycol-1000 stabilizes wood by bulking the fibers. It also serves as a chemical seasoning agent, suppresses decay in high concentrations, and has slight effect on physical properties, gluing, or finishing.

Fig. 1.—Cross sections of a southern pine log (11 inches diam., 1.25 inches thick) slowly air dried from the green condition at 90, 65, and then 30% relative humidity. Upper left: water-soaked control; upper right: 8 hours' soak in 30% aqueous solution of polyethylene glycol-1000; lower left: 16 hours' soak in the solution; lower right: 48 hours' soak in the solution.

POLYETHYLENE GLYCOL OF various molecular weights has previously been shown by the author (13)[3] to reduce greatly the shrinkage of thin cross sections of Sitka spruce. After the cross sections were completely filled with a 25 percent aqueous solution of polyethylene glycol of average molecular weight 200, the specimens were slowly air-dried and then oven-dried. They retained their green dimensions, which indicated that the polyethylene glycol had completely replaced the water in the swollen cell walls. Polyethylene glycol–1000 was only slightly less effective in replacing the water as drying progressed.

Cross sections of the wood treated with the high-molecular-weight material tended to be damp only when the equilibrium relative humidity exceeded 90 percent, while those treated with the lower-molecular-weight material tended to remain damp at appreciably lower relative humidities. For this reason, polyethylene glycol–1000 was chosen for further research.

Stabilization of Tree Cross Sections

It appeared from the previous data (13) that polyethylene glycol might serve as a chemical seasoning agent in the same manner as salt and urea (6). It was tried, therefore, in the seasoning of tree cross sections to determine if it would prevent the formation of the familiar V-shaped radial checks that open in tree cross sections.

Twelve tree ross-section discs 1.25 inches thick by 10 to 11 inches in diameter where cut from two green southern pine logs. Small brass nails were driven into one face of each disc near the cambium. They were placed on two lines at right angles to each other that passed through the center of the specimens. These served as reference points for measuring the radial shrinkage.

Three discs from each log were soaked in water overnight. The diameters were measured between the nails, and the discs were then placed in the 90 percent relative humidity room. Five discs from each log were soaked in a 30 percent (by weight) solution of polyethylene glycol–1000 in water. Discs were removed after 8, 16, 48, 96, and 168 hours, soaking, placed in the 90 percent relative humidity room, and the diameters measured immediately. Four other discs from each log were placed in the 90 percent relative humidity room, a liberal coat ranged from 0.075 to 0.105. Only one of the treated specimens showed any of molten polyethlene glycol–1000 applied to both faces of each disc with a brush, and the diameters measured. Twenty-four hours later, three of the discs from each log were given a second coat of the molten polyethylene glycol. After a second period of 24 hours, two of the discs were given a third coat, and after a third 24-hour period, one of the discs from each log was given a fourth coat.

Three weeks after the first specimens were placed in the 90 percent relative humidity room, the discs from all treatments were transferred to the 65 percent relative humidity room. A day or two after the transfer, all of the untreated controls started to develop V-shaped checks, and at the end of 2 weeks they had opened up at the periphery anywhere from 0.9 to 1.5 centimeters. The ratios of width of the checks at the periphery to the radius

The Author: Alfred Stamm holds a BS degree from the California Institute of Technology, and MS and PhD degrees from the U. of Wisconsin. He joined the FPL in 1925, and has contributed much to fundamental knowledge of wood-liquid relations.

[1] Dr. Stamm is now an associate professor of wood chemistry at North Carolina State College, Raleigh.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

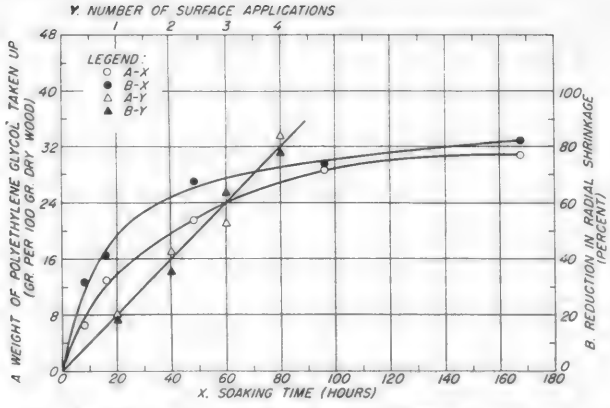


Fig. 2.—Weight of polyethylene glycol-1000 (A) taken up by green southern pine tree cross sections from a 30% aqueous solution and from surface applications of the molten chemical, together with the accompanying reduction in shrinkage (B), plotted against the soaking time (X) and the number of surface applications applied a day apart at 90% relative humidity (Y).

significant checks, namely, one of those that had a single coat of molten polyethylene glycol. The ratio of the check width to the radius of this single specimen was 0.034.

After 2 weeks in the 65 percent room, all specimens were transferred to the 30 percent relative humidity room. After two more weeks, the checks of the controls had opened up still further. The ratios of width of check to the radius of the discs ranged from 0.142 to 0.192. The check in the disc that had received one surface coat of molten polyethylene glycol had by then opened up to a width-to-radius ratio of 0.124. During this last period, the other specimen that had received one coat of molten polyethylene glycol developed a very slight check with a width-to-radius ratio of 0.016. The two discs that had been soaked in polyethylene glycol for 8 hours developed slight internal radial checks that did not extend to the periphery. All of the other specimens were free from checks.

The polyethylene glycol content of the discs was determined by cutting a small wedge-shaped specimen from the discs, cutting it up into thin shavings, oven-drying and weighing the shavings, impregnating them with water by the vacuum desiccator technique, and boiling them in a large volume of fresh water once a day for several days. They were allowed to stand in the water for the periods between heating. The extracted shavings were then oven-dried and weighed. The polyethylene glycol content was calculated from the loss in weight after a correction was made for the extractive loss of the controls.

The polyethylene glycol content of the various discs together with the radial shrinkage to 30 percent relative humidity, the reduction in shrinkage due to the bulking, and the average check widths divided by the discs radius are given in Table 1. Fig. 1 is a photograph of an untreated and three treated southern pine discs. Fig. 2 gives both the weight of polyethylene glycol–1000 taken up by the tree cross sections, and the reduction in radial shrinkage plotted against the time of soaking and against the number of surface coatings.

The data show that a polyethylene glycol content of 13 percent or more caused a reduction in radial shrinkage of 32 percent or more, and prevented the V-shaped checks from forming. The relationships plotted against the time of soaking are parabolic, and those plotted against the number of surface coatings are linear, as would be expected. An overnight, or longer, soak in a 30 percent solution of polyethylene glycol–1000 or two surface coats a day apart, it appears, will prevent the V-checks in green sapwood discs of southern pine 1 to 1.25 inches thick. As the thickness of the discs increases, the soaking time will have to be increased—probably in proportion to the square of the thickness.

Heartwood will require more soaking time or more coats than will sapwood. Two tree discs of ponderosa pine 1.5 inches thick by 18 inches in diameter were coated with two applications of molten polytheylene glycol a day apart. Fig. 3 shows the dried control (left) and the dried coated disc (right). The two coats were adequate to stabilize the outer sapwood but not the heartwood, as seen by the two narrow honeycomb checks in the heartwood. If the disc had been held under nondrying conditions for a longer time to allow deeper diffusion of the coatings into the heartwood, or if more coats had been applied to the center heartwood than to the outer sapwood the honeycomb checks might have been prevented.

WHAT THIS RESEARCH MEANS

A method for simultaneously seasoning wood and giving it dimensional stability is described. It is already in use to avoid the face checking of decorative objects that are roughly precarved from green wood. The roughly precarved wood is soaked overnight in a 30 percent solution of polyethylene glycol-1000. It can then be air dried without checking, and can be finally carved to the finished dimensions. It is felt that this procedure could be equally well adapted for making curved furniture parts, lamp stands and other decorative objects, and possibly gun stocks. This report shows that the treatment has only a minor effect upon the strength properties of wood, and does not seriously affect gluing or finishing.

Rate of Diffusion of Polyethylene Glycol-1000 into Water-Saturated Wood

The previous investigations showed that polyethylene glycols in concentrated aqueous solutions swell wood more than does water alone (13). This makes it possible to determine the diffusion coefficient of polyethylene glycol into water-saturated wood simply by following the rate of swelling in the tangential direction, the direction in which practically all swelling beyond the swelling in water occurs (9).

A cross section of Sitka spruce with a thickness in the fiber direction of 0.165 inch was saturated by immersing it in water under a vacuum for 1 hour, followed by soaking overnight under atmospheric pressure. The water-saturated specimen was immersed in molten polyethylene glycol–1000 at 60° C., and the increase in tangential dimension was measured periodically. Fig. 4 is a plot of the tangential swelling beyond that in water plotted against the square root of time. The relationship is linear up to two-thirds of the final swelling. This would be expected for true diffusion when the concentration gradient is parabolic (12, 15). The diffusion coefficient, *D*, was calculated from the data by means of the Boltzmann modification of Fick's general diffusion equation (12, 15).

$$D = \frac{\pi a^2 E_a^2}{16t} \qquad (1)$$

where a is the thickness of the specimen and E_a is the amount of solute that diffuses into the specimen in time t expressed as a fraction of the final equilibrium amount. The author has previously shown (5) that the fractional swelling, E_s, can be substituted for the fractional take-up of solute,

Table 1.—EFFECT OF POLYETHYLENE GLYCOL TREATMENTS UPON CHECKING AND SHRINKING OF SOUTHERN PINE TREE CROSS SECTIONS 1.25 INCHES THICK

Treatment	Chemical content	Average radial shrinkage[1]	Reduction in shrinkage	Average ratio of check widths to radii[1]
	Percent	Percent	Percent	
None	0	2.2[2]	0	0.158[2]
Hours of soaking[3]				
8	6.7	1.5	32	none
16	12.9	1.3	41	none
48	21.7	.7	68	none
96	28.9	.6	73	none
168	30.9	.4	82	none
Number of surface coats[4]				
1	7.7	2.0	18	0.070
2	16.9	1.4	36	none
3	20.9	.8	64	none
4	38.5	.5	78	none

[1] Dried to 30 percent relative humidity.
[2] Average for six discs; other values are the average for two discs.
[3] Soaked in 30 percent solution of polyethylene glycol-1000.
[4] Coated with molten polyethylene glycol-1000.

Table 2.—DIFFUSION OF POLYETHYLENE GLYCOL-1000 INTO 1/16-INCH-THICK EDGE-GRAIN SITKA SPRUCE VENEER UNDER DIFFERENT MOISTURE CONTENT CONDITIONS

Before polyethylene glycol application		After polyethylene glycol application		
Moisture content	Swelling from oven-dry condition	Amount applied as surface coatings	Swelling 5 weeks after application	Moisture plus chemical absorbed
Percent	Percent	Percent	Percent	Percent
	At equilibrium with 30 percent relative humidity			
4.4	0.64	0	0.64	4.4
4.4	.65	18.7	.65	4.4
4.4	.63	21.1	.63	4.4
	At equilibrium with 65 percent relative humidity			
9.6	1.46	0	1.46	9.6
9.6	1.47	26.6	1.67	11.0
9.5	1.46	24.2	1.64	10.7
	At equilibrium with 80 percent relative humidity			
13.3	1.91	0	1.91	13.3
13.5	1.99	23.9	2.34	15.9
13.3	1.99	22.8	2.36	15.8
	At equilibrium with 90 percent relative humidity			
17.9	2.58	0	2.58	17.9
17.7	2.59	25.5	3.01	20.6
17.8	2.56	19.9	2.96	20.6

E_a, at $E_a = 0.667$, since they are equivalent. D was then calculated from the thickness a and time corresponding to $E_s = 0.667$. This gave a value of $D = 0.32 \times 10^{-5}$ cm.²/sec.

The diffusion coefficient of solutes into water-saturated wood in the fiber direction, D_1, has previously been shown to be related to the bulk diffusion coefficient, D_o, as follows (11):

$$D_1 = D_o (1 - d/d_o) \quad (2)$$

where d is the specific gravity (dry-weight green-volume) of the swollen wood and d_o is the specific gravity of wood substance determined in water. The experimental values of 0.365 for d and of 1.52 for d_o (8) when substitute in equation (2) give $D_o = 0.42 \times 10^{-5}$ cm.²/sec. No data are available for the bulk diffusion constant of polyethylene glycols. If Graham's law, which states that the diffusion coefficients are inversely proportional to the square root of the molecular weight, is assumed to hold, and if the diffusion coefficient increases 1.4 times for each raise of 10° C., which is the case of glycerine, mannitol, and sucrose, then the theoretical diffusion coefficient would be 0.48×10^{-5} cm.²/sec.

For dilute solutions, the calculated coefficient does not vary greatly from the experimental value obtained with concentrated solutions. Tre data indicate that polyethylene glycol–1000 will just reach the center of a specimen 0.70 inch in the fiber direction in 24 hours. From measurements of the relative rates of diffusion of salts into wood in the three structural directions (2, 11), it can be predicted that it would take about 10 to 15 days for the polyethylene glycol–1000 to reach the middle of long green boards 0.70 inch thick in either of the transverse directions. Soaking times for long boards would thus have to be quite long to allow for adequate transverse take-up of chemical.

The diffusion coefficient for the polyethylene glycol into the green cross sections of southern pine from the 30 percent solution was also calculated from the data of Fig. 2. A value of 0.5×10^{-5} cm.²/sec. was obtained. This slightly larger value can be accounted for on the basis that some capillary absorption took place, since the wood, although green, was not completely saturated with water.

Diffusion into Wood at Different Moisture Contents

A means of dimensionally stabilizing wood in service has long been sought. Therefore, it seemed worth while to determine how well a surface application of polyethylene glycol penetrates the cell-wall structure of wood at different moisture contents. Twelve specimens of edge-grain Sitka spruce veneer 1/16 inch thick by 5 inches in the radial direction and 3 inches longitudinally were oven-dried, weighed, and their radial dimension measured. Three specimens were placed in each of the following relative humidity rooms: 30, 65, 80, and 90 percent; they were allowed to come to equilibrium moisture content, after which the weight increase and radial swelling were determined. A coat of molten polyethylene glycol was applied to both faces of two sheets out of each set of three sheets of the veneer. After the sheets remained in the same relative humidity room for five more weeks, the radial dimension of the veneer was again measured. No change occurred for the controls or the coated specimens in the 30 percent relative humidity room.

The coated specimens in the higher relative humidity rooms all showed additional swelling that increased with an increase in the relative humidity. The data are given in Table 2. They show that polyethylene glycol must have diffused into the cell walls, and that the amount that entered exceeded the amount of water displaced. At 90 percent relative humidity an amount of polyethylene glycol equivalent to at least 2.8 percent of the weight of the wood must have diffused into the cell-wall structure. Even at this high rela-

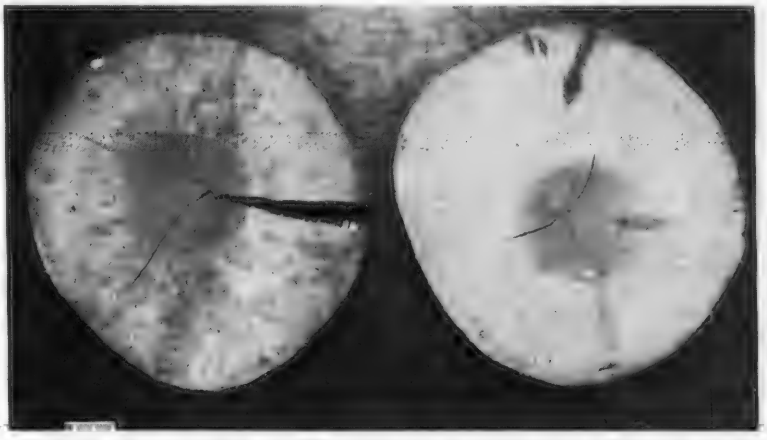


Fig. 3.—Cross sections of ponderosa pine log (18 inches diam., 1.5 inches thick) slowly air dried at 90, 65, and then 30% relative humidity. Left: water-soaked control; right: 2 surface applications of polyethylene glycol-1000 a day apart at 90% relative humidity.

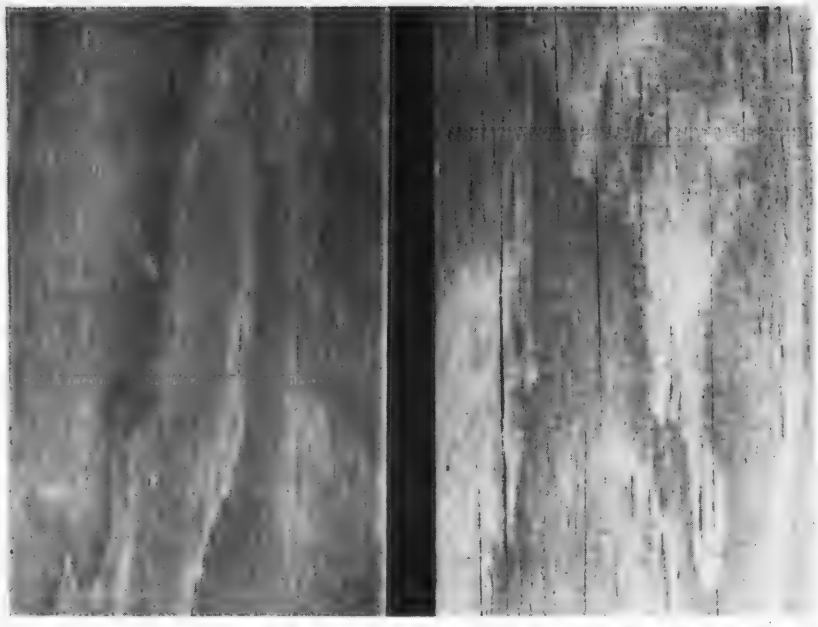


Fig. 5.—Surfaces of 2 Douglas-fir plywood panels that had alternately been exposed to 4 cycles of 90% relative humidity for 2 weeks followed by 30% relative humidity for 2 weeks. Left: panel with untreated faces; right: panel the faces of which were impregnated with 30% of polyethlene glycol-1000 prior to bonding to an unimpregnated core.

tive humidity, the amount of bulking afforded by polyethylene glycol that diffuses into the cell wall is very small compared to that caused by diffusion into the cell walls of green wood. Even in humid climates, the application of polyethylene glycol to such things as layed floors would not be very effective in swelling them tight.

Reduction in Face Checking of Plywood

Eight sheets of dry ⅛-inch-thick, rotary-cut Douglas-fir veneer of four types, namely, 1) tangential grain containing considerable compression wood, 2) tangential grain, slow growth, 3) partly edge grain slow growth, and 4) tangential grain, fast growth, were each cut into four end-matched, 1-foot-square specimens. One specimen from each sheet was impregnated with 10, 20, and 30 percent solutions of polyethylene glycol–1000 and with water to obtain about a 100 percent weight increase. The impregnation was done in a treating cylinder at 200 psi for several hours.

The average polyethylene glycol contents attained were 10.8, 20.2, and 32.2 percent, respectively. In all cases the compression wood specimens took up only about 75 percent as much solution as the others. The test pieces were air-dried to 30 percent relative humidity and then glued up as faces and backs to 3/16-inch untreated Douglas-fir veneer cores to form three-ply plywood. A hot-setting phenolic resin glue was used. The glue was spread with a hand roller on the core sheets to give a single glue line of 35 pounds per 1000 square foot. The pressing was for 10 minutes at 285° F. under a pressure of 175 psi. Good glue bonds were obtained in all cases.

The 16 plywood panels were cycled four times between 90 and 30 percent relative humidity. No checks appeared in the panels treated to the two highest degrees. Three of the four panels that contained only 10.8 percent of polyethylene glycol had a few hairline checks. All of the four controls showed medium to bad checking. Fig. 5 shows a control panel (left) and a panel with faces that contain 30 percent of polyethylene glycol–1000 (right). The polyethylene glycol treatment was quite effective in minimizing face checking of the Douglas–fir plywood.

In practice it appears more advantageous to soak green veneer in a concentrated solution of polyethylene glycol in water or in the molten polyethylene glycol at 60° to 90° C. rather than to impregnate dry veneer. A few preliminary measurements indicate that the required soaking time for 1/10-inch-thick veneer in molten polyethylene glycol–1000 at 60° C. would be between 4 and 8 hours, depending on the moisture content of the veneer (60 to 40 percent). The green veneer could also be impregnated by passing it between compression rolls beneath the surface of the hot treating solution. As the veneer recovers from the compression, it will suck in the solution (10).

Strength Tests

Tests were made to determine the effect of polyethylene glycol treatment upon the toughness, abrasion resistance, modulus of rupture, and modulus of elasticity of wood. The first two tests were made primarily because they are very sensitive to treatments that cause embrittlement of wood, such as resin treatment (4) and heat stabilization and formaldehyde cross-linking (14, 16). In the two latter cases the values may be reduced to one-twentieth of the values for untreated wood (14).

The toughness tests were made with the small Forest Products Laboratory toughness tester (19) on ¼- by 1/16-inch strips of edge-grain Sitka spruce veneer 3 inches long in the fiber direction. Five end-grain matched specimens, 3 inches in the fiber direction by 5 inches radially were cut from each of four strips of 1/16-inch-thick veneer. One specimen from each of the strips was impregnated by the vacuum desiccator technique with each of the following concentrations of polyethylene glycol–1000 dissolved in water; 0, 10, 20, 30, and 40 percent. The specimens were air-dried at 65 percent relative humidity followed by 30 percent relative humidity, and were then oven-dried, weighed, and the radial dimension measured. They were then reconditioned to 65 percent relative humid-

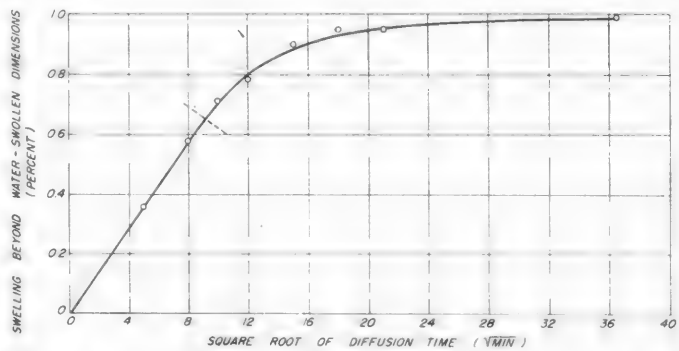


Fig. 4.—Rate of swelling of a water-saturated cross section of Sitka spruce (0.165 inc thick) beyond the water-swollen condition in the tangential direction when immersed i molten polyethylene glycol-1000 at 60° C. Cross line is at two-thirds of the final swelling.

Table 3.—EFFECT OF IMPREGNATING 1/16 INCH THICK EDGE GRAIN SITKA SPRUCE VENEER WITH POLYETHLENE GLYCOL-1000 UPON THE DIMENSIONAL STABILITY AND ON THE TOUGHNESS

Chemical content[1]	Reduction in swelling[1, 2]	Relative toughness[3]
Percent	Percent	
0.0	0	1.00
1.1	44	.99
9.6	68	1.04
25.3	78	1.02
41.6	80	1.08

[1]Average for four specimens 5 inches radially by 3 inches longitudinally.
[2]From oven-dry to equilibrium with 65 percent relative humidity.
[3]Average for 10 specimens 0.25 inch radially by 3 inches longitudinally cut from each of the four original specimens.

Table 4.—EFFECT OF IMPREGNATION 1/16-INCH-THICK ROTARY-CUT YELLOW BIRCH VENEER WITH POLYETHLENE GLYCOL-1000 UPON THE RELATIVE ABRASION RESISTANCE

Chemical content	Specific gravity[1]	Relative abrasion resistance[2]	Ratio, relative abrasion resistance to specific gravity
Percent			
0.0	0.62	1.0	1.61
9.8	.60	1.04	1.73
21.3	.56	.98	1.66
33.8	.53	.82	1.55

[1]Based on unimpregnated dry weight and impregnated volume.
[2]Each value is the average for 4 specimens at 5 arbitrarily chosen fixed points for 100 revolutions of the disc.

ty, weighed, and measured. Each of the specimens was cut into ten ¼-inch-wide strips for the toughness tests.

Table 3 gives the polyethylene glycol content of the specimens, the reduction in swelling from the oven-dry to equilibrium with 65 percent relative humidity caused by the treatment, and the average toughness of 40 specimens relative to that of the unimpregnated control. The data show that the treatment has virtually no effect upon the toughness of the material up to treating levels of 45 percent, with a resulting dimensional stabilization of 80 percent.

The abrasion-resistance tests were made with the Navy abrader (3, 18) on rotary-cut birch veneer specimens 2.75 inches long by 2 inches wide glued to supporting blocks. Fresh aluminum oxide grit No. 80 continuously flowed onto the grinding plate. The data are given in Table 4. At the higher polyethylene glycol contents, the abrasion resistance decreases by an amount approximately proportional to the specific gravity (unimpregnated weight/impregnated volume), which is reduced due to the bulking of the fibers.

A flat-grain board of Sitka spruce 0.5 inch thick was cut into 12 side-matched strips 0.5 inch wide by 26 inches long. Each of these was in turn cut into two 13-inch-long, end-matched specimens. Sets of four side-matched specimens were impregnated with each of the following concentrations of polyethylene glycol–1000 in water: 10, 20, and 30 percent. All 12 of the end-matched specimens were similarly impregnated with water to serve as controls. The sticks were air-dried and conditioned to 65 percent relative humidity. Static bending tests were made on each stick in the tangential direction. The data expressed as values relative to those for the end-matched controls are given in Table 5. The various strength properties decrease slightly to moderately with increasing polyethylene glycol content. In each case, the ratios for the highest chemical content are either higher or about equal to the corresponding ratios for the properties of green wood relative to wood at 12 percent moisture content. In no cases is the loss in strength due to impregnation with polyethylene glycol significantly greater than would be expected from the extent of bulking of the fibers, which is indicated by the decrease in the ratio of the specific gravities.

Decay Resistance

A flat-sawn Sitka spruce board 5 inches wide by 0.5 inch thick was cut into a series of specimens 0.5 inch in the fiber direction for decay-resistance tests. The specimens were impregnated by the vacuum desiccator technique with 0, 5, 10, 20, and 40 percent solutions of polyethylene glycol–1000 dissolved in water- resulting in polyethylene glycol contents of the wood ranged from 8.6 to 63.7 percent. The specimens were air-dried to equilibrium with 30 percent relative humidity and then subjected to the standard block culture test (1) for 3 months after inoculation with *Lenzites trabea* 517. Because washing to remove the fungus and decay products also extracted polyethylene glycol from the specimens, the weight-loss technique for determining the amount of decay could not be used. The extent of decay was thus judged qualitatively by the ease of penetration of a knife blade into the structure. All specimens that contained at least 17.6 percent of polyethylene glycol were perfectly sound. Specimens that contained only 8.6 percent of polyethylene showed some evidence of decay, while the controls were badly decayed. Culture tests showed that polyethylene glycol–1000 is nontoxic. The practical elimination of decay occurred when the reduction in swelling was 50 percent and more. Under these conditions only half of the normal amount of water can enter the fiber. This evidently is insufficient to support decay.

Gluing Tests

A number of the potential applications of the polyethylene-glycol-treated wood will depend upon its gluability. To determine this factor, two sheets of rotary-cut yellow birch veneer 1/16-inch thick were each cut into 4 strips 5 inches wide in the tangential direction and parallel to a split edge in order to get the grain as straight as possible. The strips were cut into twelve 3-inch lengths, which gave a total of 96 3-inch by 5-inch pieces of veneer. The experiment involved 3 levels of treatment and an untreated control, 6 different glues, and 2 specimen replications, each of which consisted of 2 specimens glued together to form lap joints. Pieces cut from one sheet were in all cases glued to the corresponding treated piece from the other sheet. The four levels of treatment for bonding with each glue were the longitudinally adjacent pieces from the same strip. Replications were either from the same strip or from adjacent strips. In this way, the best matching occurred between the different levels of treatment, the variable of chief concern in this study.

The pieces of veneer were impregnated with 0, 5, 10, and 20 percent aqueous solutions of polyethylene glycol–1000 to give chemical contents ranging from 8 to 33 percent. The treated pieces were then dried to equilibrium at 30 percent relative humidity.

Paired specimens of the treated and conditioned veneer were glued together with the end grain of each overlapping the other by 1 inch, thus giving a 5-inch by 5-inch specimen. The 6 glues —casein, polyvinly emulsion, cold-setting urea resin, cold-setting resorcinol resin, hot-setting phenolic resin, and a hot animal glue—were all applied in accordance with recommended procedures (7, 17).

The glued specimens were conditioned at 30 percent relative humidity for 10 days, and then each was cut into 4 test specimens 1 inch wide. The strength of the glued joint was determined by measuring the tensile load required to break the specimen and estimating the percentage of wood failure. The data are given in Table 6. The casein, cold-setting urea and hot-setting phenolic glues all gave consistently high tensile strength and high percentages of wood failure. The poly-

Table 5.—RATIO OF THE PHYSICAL AND STRENGTH PROPERTIES[1] OF SITKA SPRUCE STICKS (0.5 BY 5 BY 13 INCHES) IMPREGNATED WITH POLYETHYLENE GLYCOL-1000 TO THE VALUES FOR END-MATCHED UNIMPREGNATED CONTROLS (THIRD-POINT TANGENTIAL LOADING)

Chemical content	Specific gravity[2]	Modulus of elasticity	Fiber stress at proportional limit	Modulus of rupture	Work to proportional limit	Work to maximum load
Percent						
15.3	0.94	0.99	0.74	0.87	0.55	1.18
30.5	.94	.90	.57	.67	.38	.70
45.5	.94	.85	.46	.62	.27	.81
			Ratio of green wood to wood at 12 percent moisture content[3]			
	.92	.78	.49	.56	.33	.67

[1]Averages of four values.
[2]Based on dry unimpregnated weight and impregnated volume.
[3]U.S.D.A. Agriculture Handbook No. 72 (1955).

vinyl emulsion, cold-setting resorcinol, and hot animal glues gave somewhat decreasing tensile strengths and decreasing or irratic percentages of wood failure with increasing polyethylene glycol contents.

Confirmatory tests were made on a duplicate set of samples. In the second series, both the polyvinyl emulsion and the resorcinol glues still showed a tendency to decrease in tensile strength with an increase in polyethylene glycol content, but they did give higher wood failures. The hot animal glue gave good tensile values that did not decrease with increasing polyethylene glycol content, and more consistently high wood failure values. The lowest tensile strength value obtained in the second series was 450 psi with a wood failure of 12 percent for the cold-setting resorcinol resin and the highest polyethylene glycol content. The data thus indicated that quite good glue joints can be obtained for wood containing as much as 33 percent of polyethylene glycol. Casein, cold-setting urea, and hot-setting phenolic resin gave the best results.

The marked suitability of hot-setting phenolic resin for gluing the treated veneer was noted above in the discussion of the face-checking tests. The cycling of the glued-up panels between 90 and 30 percent relative humidity set up a very severe stress at the glue line. None of the panels showed any sign of deliminating under this rigorous treatment.

Finishing Tests

Standard ponderosa pine paint-test panels 2-5/8 inches wide by 1/4 inch thick were each cut into two equal 5.5-inch lengths. One half of each of the end-matched specimens was impregnated with polyethylene glycol solution and the other half with water by the vacuum desiccator technique. Three concentrations were used, namely, 10, 20, and 40 percent; these gave polyethylene glycol contents of 10 to 13 percent, 18 to 24 percent, and 36 to 50 percent on the basis of the dry weight of the wood. This variability was due to the nonuniformity of the wood. The specimens were all dried at 65 percent and then 30 percent relative humidity.

Seven different finishes were applied to the specimens. These were a floor sealer, shellac, phenolic resin spar varnish, alkyd resin clear varnish, a clear lacquer, natural exterior finish (Forest Products Laboratory No. 497), and an exterior white paint. Two coats of each finish were applied to three specimens that contained the three different amounts of polyethylene glycol and their corresponding controls.

The panels were inspected 24 hours after application of the first coat. In all cases the specimens that contained polyethylene glycol were much more tacky than the control,s which indicates that drying was retarded by the chemical. The panels were hence allowed to dry for a few more days before application of the second coat. Three days after the second coat was applied, all of the specimens treated with polyethylene glycol were somewhat tacky, especially the ones containing the largest amount.

Two months later the panels were carefully examined. All of the impregnated panels with clear finishes were lighter in color than the unimpregnated controls. This was especially noticeable with the varnishes. The panels that contained the two lower levels of polyethylene glycol were dry to the touch like the unimpregnated controls. The specimens containing the largest amount of polyethylene glycol that were coated with floor sealer and shellac were also dry. All of the others had a slight tendency to bond to one's finger when pressed firmly on the surface.

The slow drying of the finishes can be partly attributed to the fact that the finishes were applied during the humid summer months. Three coats of a polyurethane varnish and three coats of outside white paint were applied to redwood specimens for leaching tests described later. The finishes were applied at 30 percent relative humidity. Three days after the final coats, the varnish was dry on the polyethylene glycol-impregnated specimens, but the outside white paint was still slightly tacky. Excepts for the retarded rate of drying, it appears that polyethylene glycol-impregnated wood can be satisfactorily finished.

Leaching Tests

It is well known that all wood finishes are somewhat permeable to water (5). There was a question, however, whether they would be permeable to polyethylene glycol with a molecular weight of 1000. Experiments were made to determine if varnish or paint finishes acted as semipermeable membranes and tended to retain polyethylene glycol within the wood under leaching conditions, and also to determine if the osmotic action tended to blister or loosen the films from the wood.

A 0.75-inch-thick, edge-grain redwood board 3.75 inches wide was cut into 3-inch-long specimens in the fiber direction. All corners and edges were rounded by sanding. Eight specimens were impregnated with a 30 percent solution of polyethylene glycol-1000 to give an average chemical content of 39 percent. These specimens together with an untreated control were conditioned to 30 percent relative humidity. Three of the impregnated specimens were given three coats of a polyuroethane varnish and three were given three coats of a commercial white house paint. When the finishes were dry, the specimens were weighed and measured. These six specimens together with the two impregnated but uncoated specimens and the unimpregnated uncoated specimen were immersed in running water for two weeks. The weight increase of the unimpregnated nonsurface-coated specimen was 57 percent. The impregnated but non-surface coated specimens increased on the aver

Table 6.—EFFECT OF POLYETHLENE GLYCOL-1000 ON THE GLUING OF YELLOW BIRCH VENEER

Glue	Tensile strength of glue joint for chemical content of [1,2]				Wood failure at glue joint for chemical content of[2]			
	0 percent	8 percent	15 percent	33 percent	0 percent	8 percent	15 percent	33 percent
	Psi	Psi	Psi	Psi	Percent	Percent	Percent	Percent
Casein	712	726	722	778	57	64	93	78
Polyvinyl	875	804	622	470	52	27	29	15
Cold-setting urea	600	590	590	583	64	89	92	97
Cold-setting resorcinol	672	552	360	352	30	42	0	0
Hot-setting phenolic	590	575	573	606	75	74	82	88
Hot animal	675	676	795	533	8	0	47	3

[1]Specimens 1 inch wide by 1 inch overlap.
[2]Each value is the average of 8 determinations.

age 53 percent in weight. The average increase in weight of the varnished specimens was only 2.6 percent, and of the paint-coated specimens, 3.8 percent. This small weight increase merely raised the average moisture content of the specimens from 7 percent to 10 to 11 percent. Under these conditions, polyethylene glycol was not leached out to any measurable degree.

The specimens were oven-dried, weighed, and measured. The impregnated specimens that were not surface-coated had lost a little over half of their polyethylene glycol during leaching. The paint-coated specimens blistered during the drying, but the varnish-coated specimens did not. It thus appears that, in spite of the fact that polyethylene glycol can be readily leached from wood, a good surface coating retains practically all of it in the wood.

Conclusions

Polyethylene glycol-1000 is shown to be a good seasoning and dimension-stabilizing agent for wood. Although an amount of chemical equivalent to about 30 percent of the dry weight of the wood is required to give high degrees of dimensional stabilization, less is needed to cut down face checking that results from seasoning and occurs due to humidity changes in service.

Although the chemical can be leached from wood, surface coatings do an excellent job of keeping them in the wood.

The toughness of wood is not reduced by the treatment as is the case for most other dimension-stabilizing agents. Static-bending and abrasion-resistence properties are reduced only to the extent that would be expected from the bulking of the fibers.

The treated wood has good decay resistance and can be readily glued and finished, but the rate of drying of finishes is greatly retarded.

Literature Cited

1. American Society for Testing Materials. 1956. Tentative method of testing wood preservatives by laboratory soil block cultures. D1413-56T (1956).
2. Burr, H. K., and A. J. Stamm. 1947. Diffusion in wood. J. Phys. Colloid Chem. 51:240.
3. Cizek, A. W., D. H. Kollos, and H. Nestlen. 1945. A new machine for measuring wear resistance of walkway materials. ASTM Bull. No. 132.
4. Erickson, E. C. O. 1952. Mechanical properties of laminated modified wood. Forest Prod. Lab. Report No. R1639.
5. Hunt, G. M. 1930. Effectiveness of moisture excluding coatings on wood. Circular 128, U. S. Dept. Agr.
6. Loughborough, W. K. 1948. Chemical seasoning: Its effectiveness and present status. Forest Prod. Lab. Report No. D1721.
7. Olson, W. Z., and R. F. T. Blomquist. 1953. Gluing techniques for beech. Beech Utilization Series No. 5, Northeastern Forest Experiment Station, Forest Service, U. S. Dept. Agr.
8. Stamm, A. J. 1929. Density of wood substance adsorption by wood and permeability of wood. J. Phys. Chem. 33:398.
9. Stamm, A. J. 1934. Effect of inorganic salts upon the swelling and the shrinking of wood. J. Am. Chem. Soc. 56: 1195.
10. Stamm, A. J. 1944. Wood impregnation. U. S. Patent 2,350,135, May.
11. Stamm, A. J. 1946. Passage of liquids, vapors, and dissolved materials through softwoods. U. S. Dept. Agr. Tech. Bull. 929.
12. Stamm, A. J. 1956. Diffusion in cellulosic materials. Australian Pulp and Paper Ind. Tech. Assoc. Proc. 10:244.
13. Stamm, A. J. 1956. Dimensional stabilization of wood with Carbowax. Forest Prod. J. 6(5):201.
14. Stamm, A. J. 1959. Dimensional stabilization of wood by thermal reactions and formaldehyde cross-linking. Tappi 42:39.
15. Stamm, A. J. 1959. Bound-water diffusion into wood in the fiber direction. Forest Prod. J. 9(1):27.
16. Tarkow, H., and A. J. Stamm. 1953. Effect of formaldehyde treatments upon the dimensional stabilization of wood. Forest Prod. Research Soc. J. 3(2):33.
17. Truax, T. R. 1929. The gluing of wood. U. S. Dept. Agr. Bull. No. 1500.
18. Youngquist, W. G., and B. P. Munthe. 1948. The abrasion resistance of wood as determined with the U. S. Navy wear-testing machine. Forest Prod. Lab. Report No. R1732.
19. U. S. Forest Products Laboratory. 1941. Forest Products Laboratory toughness testing machine. Report No. 1308.

Separating Lignosulfonates from Carbohydrates

IN ASPEN SPENT SULFITE LIQUOR BY ION EXCHANGE[1,2]

I. A. Pearl and D. L. Beyer
The Institute of Paper Chemistry, Appleton, Wis.

Essentially complete separation of the lignosulfonate and carbohydrate fractions of aspen spent sulfite liquors can be obtained by first decationizing the spent liquor and then passing it over a regenerated column of Duolite A-2M. The carbohydrate materials are found in the effluent, and the lignosulfonate materials are found in the alkaline eluate of the column.

Earlier studies on the attempted separation of the lignosulfonates from the carbohydrates present in aspen spent sulfite liquor have been reported (1,2). These studies included experiments on cellulose column chromatography, ion exclusion, solvent extraction, and fractional precipitation in which the authors were able to separate, identify, and quantitatively determine the various sugars present, but were unable to isolate lignosulfonate fractions free from carbohydrate impurities. The need for carbohydrate-free aspen lignosulfonates for oxidation studies led to continued studies, and the present paper describes investigations on the use of ion-exchange resins for accomplishing the separation.

Van Blaricom and Gray (3) have described the preparation of anion-exchange resins and their use for separating the lignosulfonate fraction of ammonia-base coniferous spent sulfite liquor. These investigators found that best results were obtained with porous anion-exchange resins in the basic state, in which the basic radicals were substantially all tertiary amino groups. Complete separation of carbohydrate and lignosulfonate fractions was not reported, but procedures for recovery of lignosulfonate fractions free from carbohydrates were noted in detail. Further fractionation of these carbo-

The Authors: Irwin A. Pearl is Senior Research Associate and Chief of the Lignin Group at the Institute. He holds BS, MS, and PhD degrees from the University of Washington.

Donald Beyer holds a BS degree from Ripon College. A Research Aide, he joined the Institute in 1946 after Army service.

[1] Presented at Session XVII, Chemical Utilization, FPRS 13th National Meeting, June 28-July 3, 1959, San Francisco.

[2] This paper is the third in a series based on a research program sponsored by the Sulphite Pulp Manufacturers' Research League at the Institute. Acknowledgement is made by the Institute for permission from the League to publish these results. For paper II of this series, see Pearl, I.A., D. L. Beyer, and E. E. Dickey. 1958. J. Org. Chem. 23:705.

hydrate-free lignosulfonate fractions on phenolic ion-exchange resins was reported more recently (4).

An attempt was made to apply this anion-exchange method to the separation of lignosulfonates from carbohydrates in aspen spent sulfite liquor. Two commercial ammonia-base liquors of mixed aspen origin were employed in this study. One liquor (Liquor I) was a digester-strength whole aspen spent sulfite liquor, and the other (Liquor II) was an ether-extracted concentrated aspen spent sulfite liquor.

Preliminary Study

The first study comprised a series of 19 experiments. The nature and experimental conditions of individual experiments in this introductory series evolved as the study progressed, although all experiments followed the same general pattern of passing the liquor through a regenerated anion-exchange column followed by thorough washing to give an effluent fraction. The washed column was eluted with 4 percent sodium hydroxide solution and washed again to yield an alkaline eluate fraction. All fractions were analyzed for total solids and for methoxyl on the solids. They were then oxidized with nitrobenzene and alkali under the micro conditions of Stone and Blundell (5) to give the yields of syringaldehyde and vanillin. Sugar determinations by the procedure of Pridham (6) were made on the effluents, but not on the alkaline eluates. The data of these determinations made possible the calculation of a methoxyl balance on the entire operation, the amount of oxidizable lignosulfonate material tied up by the anion-exchange resin and passed by the resin, and the extent of separation of carbohydrate from lignosulfonate materials.

The first experiments that included digester-strength whole liquor and Duolite anion-exchange resins A–7, A–70, and A–6 indicated that methoxyl, vanillin, and syringaldehyde recoveries were poor under normal conditions. Hydrolysis of the liquor by boiling with sulfuric acid prior to passage through the column did not increase the methoxyl recovery, but changed the ratios of syringaldehyde to vanillin obtained on oxidation—usually through loss of recovered vanillin. Results also indicated that methoxyl was lost during the hydrolysis procedure and subsequent concentration. Experimental results similar to sulfuric acid hydrolysis were obtained by decationizing the liquor with Amberlite IR–120 cation-exchanger and concentrating it before passage through the Duolite anion-exchanger. Again, methoxyl was lost during the concentration step. Best results in these experiments were obtained with Duolite A–6 resin.

Experiments with ether-extracted concentrated aspen spent sulfite liquor on the same resins gave better methoxyl, syringaldehyde, and vanillin recoveries, but poorer separation of methoxyl between effluent and alkaline eluate. Other experiments were run with Duolite A–2M anion-exchanger and S–30 resinous absorber with and without previous decationization or hydrolysis.

A number of facts became apparent from this introductory series of ion-exchange fractionations of aspen spent sulfite liquor.

1. Unlike coniferous spent sulfite liquors, aspen spent liquors cannot be quantitatively fractionated into their carbohydrate and lignosulfonate fractions by means of several Duolite anion-exchange resins.

2. The best separation of methoxyl content of the whole original liquor was approximately 60 percent, but this could be increased by first decationizing the liquor. The Duolite resins employed in this study were essentially acid-adsorbents and not salt-splitters, and thus allowed some lignosulfonate salts to appear in the effluent.

3. Loss in methoxyl took place on hydrolysis of liquor prior to anion exchange.

WHAT THIS RESEARCH MEANS

Many uses for purified components of softwood spent sulfite liquor have been proposed in the past, and large-scale specialized commercial utilization of softwood spent liquor has resulted from some of these uses. In some parts of the country, hardwood—especially aspenwood—has replaced softwoods as the raw material for sulfite pulping. The spent sulfite liquors from these hardwoods are not amenable to many of the processes that evolved over the years for utilization of softwood spent liquors. Large-scale utilization of aspenwood spent sulfite liquor in many cases is limited because of the inability to separate lignosulfonate materials from the carbohydrate materials in the liquor.

This paper describes experiments on th separation of lignosulfonates from carbohydrates in spent sulfite liquor from aspen. Experiments indicate that essentially complete separation of lignosulfonate and carbohydrate fractions can be obtained by first decationizing the spent liquor and then passing the decationized liquor over a regenerated column of Duolite A-2M anion-exchange resin. The carbohydrate materials are found in the effluent, and the lignosulfonate materials are found in the alkaline eluate of the column. The separated components obtained by this process provide purified materials for specialized end uses. The process should result in the more complete utilization of the vast quantities of spent sulfite liquor resulting from the pulping of aspen.

4. Syringaldehyde-vanillin ratios obtained from the recovered fractions appeared to be related to the methoxyl recovery. High syringaldehyde-vanillin ratios were obtained in those experiments that gave poor methoxyl recoveries, and experiments that gave quantitative methoxyl recoveries yielded low syringaldehyde-vanillin ratios.

5. In experiments with quantitativ methoxyl recovery, the vanillin obtain able from the recovered fractions wa always higher than the syringaldehyde even though both exceeded 100 percent of that obtainable from the orig inal liquor.

6. All of the sugars appeared in th effluents from the Duolite anion-ex changers employed in this study.

7. Hydrolysis of aspen spent sulfit liquors increased the amount of sugar found in the effluent.

Fractionation of Decationized Liquors

Because the best fractionation o lignosulfonates from carbohydrates i aspen spent sulfite liquors was obtaine in those experiments in which the liq uor was decationized prior to passag through the column, a study was mad of the fractionation of decationized liq uors by a number of commerciall available anion-exchange resins. Fo this study, both Liquors I and II wer decationized with Amberlite IR–120 Eight different anion-exchangers were compared as to their efficacy in separat ing lignosulfonate and carbohydrat materials. Determinations noted for the introductory study were made on all fractions, and data are reported in Tables 1 and 2.

Discussion of Results

The data of Tables 1 and 2 indicate that the best resin for separating lignosulfonates from sugars in aspen spent sulfite liquor was Duolite A–2M, and even this resin effected separation only on a decationized liquor. Duolite A–6 also gives satisfactory separation of lignosulfonates and sugars in deca tionized aspen spent liquor. Both of these resins are porous, weakly basic acid adsorbents that contain only ter tiary amines (A–6) or primary, sec ondary and tertiary amines (A–2M) a functional groups. Another unmodifie porous, weakly basic acid adsorben with functional groups consisting o primary, secondary and tertiary amine (Duolite A–7) gave only poor an fair separations in Experiments 2 an 10, respectively. The intermediate bas icity resin, Duolite A–70, gave ver good methoxyl recovery on the deca tionized Liquor I, but the separatio obtained on both liquors was poor The strongly basic quaternary amine type resins, Duolite A–101 and A–102

and Amberlite IRA–400 and IRA–401, gave no apparent separation of the lignosulfonates and carbohydrates in either Liquor I or Liquor II.

The syringaldehyde-vanillin ratios on a molar basis indicated fractionation of lignosulfonate materials on aldehyde-yielding ability in several experiments. It should be noted that results of the nitrobenzene oxidation procedure indicate only the relative amounts of materials capable of yielding particular aldehydes upon oxidation under specific conditions, and do not necessarily indicate total amounts of syringyl and guaiacyl moities present.

It appears that aspen spent sulfite liquors may be almost quantitatively fractionated into their carbohydrate and lignosulfonate fractions by first decationizing with Amberlite IR–120. This process has no effect on the methoxyl content. The cation-free liquor is then passed through a column of Duolite A–2M anion-exchange resin. The sugars pass through the column and appear in the effluent, and the free lignosulfonic acids are held up on the resin. Alkaline elution of the column yields an alkaline solution of the lignosulfonic acids with substantially no methoxyl loss.

Starting Materials

Liquor I was a digester-strength spent sulfite liquor from the ammonium-base cooking of peeled mixed aspenwood (*Populus tremuloides, P. grandidentata,* and *P. tacamahaca*) obtained from Charmin Paper Products Co. The liquor contained 10.3 percent total solids, and the total solids contained 7.40 percent methoxyl.

Liquor II was also from an ammonium-base cook of peeled mixed aspenwood obtained from Charmin Paper Products Co. Thirty gallons of fresh digester-strength liquor was evaporated to half volume in a large laboratory circulating evaporator at a temperature below 50°C. The concentrated liquor was extracted in batches of approximately 5 liters with ether in the air-agitated liquid-liquid extractor (7). The aqueous raffinates were combined and concentrated again in the circulating evaporator to give an ether-extracted concentrated aspen spent sulfite liquor containing 40.0 percent solids and 7.93 percent methoxyl on the solids basis.

Duolite Resins: Manufactured by Chemical Process Co., Redwood City, Calif.

A–6: A porous, granular, weakly basic acid adsorbent containing only tertiary amine functional groups.

A–7: A porous,-weakly basic acid adsorbent with functional groups consisting of primary, secondary and tertiary amines.

A–2M: A modified form of Duolite A2 porous, granular, weakly basic absorbent with functional groups consisting of primary, secondary, and tertiary amines) specially designed for the separation of the carbohydrate and lignosulfonate fractions of coniferous spent sulfite liquors.

A–70: A semiporous acid adsorbent of intermediate basicity containing only tertiary amines as functional groups and with enough porosity to permit ready diffusion of large molecules.

A–101 and A–102: Strongly basic acid adsorbents of the quaternary amine type.

S–30: A resinous absorbent with very little ion-exchange capacity, but with great adsorptive capacity for many polar organic molecules.

Amberlite Resins: Manufactured by Rohm & Haas Co., Resinous Products Division, Philadelphia, Pa.

IR–120: A bead-like granular cation-exchanger of the nuclear sulfonic acid type.

IRA–400: A bead-like, strongly basic, quaternary-amine type anion-exchanger.

IRA–401: A strongly basic, quaternary-amine type anion-exchanger similar to IRA-400, but with greater porosity.

Experimental

General Procedure for Anion-Exchange: A glass column 30 mm. in diameter was filled with 400 ml. of the anion-exchange resin. The column was backwashed with water and regenerated with 4 percent sodium hydroxide solution. The resin was washed with distilled water until the effluent was neutral to alkacid paper. An amount of aspen spent liquor containing approximately 50 grams of solids was then passed through the column, which was then washed with an excess of distilled water. The effluents were treated immediately with a few drops of dilute sulfuric acid to lower the pH to 5–6 to prevent degradation of the sugars, and were then concentrated in a laboratory circulating evaporator under reduced pressure below 50°C. to give the effluent fraction. The resin column was then washed with 200 ml. of 4 percent sodium hydroxide solution and then with water until no free alkali was indicated in the effluent. The combined sodium hydroxide eluate and water wash was concentrated to a small volume in the circulating evaporator under reduced pressure to give the alkaline eluate fraction.

Aliquots of each fraction were evaporated in a vacuum oven for total solids determinations, and methoxyl values were determined on these solids by a micro-adaptation of the volumetric method of Vieböck and Schwappach (8). The fractions were then oxidized with nitrobenzene and alkali under the micro conditions of Stone and Blundell (5). According to these authors, the material is heated in small bombs with nitrobenzene and alkali, and the digestion mixtures are spotted quantitatively directly on paper. The paper chromatograms are developed, checked for location of aldehyde bands, and the cut out bands of syringaldehyde and of vanillin are eluted and determined spectrophotometrically. Similarly, the method of Pridham (6) for determination of individual sugars in the concentrated effluents consisted of chromatography of the effluents followed by spraying with *p*-anisidine reagent solution, developing a colored spot, cutting out the colored spot, eluting the color, and finally determining the absorbance spectrophotometrically.

General Procedure for Decationizing Aspen Spent Liquors: A column 65 mm. in diameter and 800 mm. in height was packed with Amberlite IR–120 cation-exchange resin to a volume of 1000 ml. The resin was backwashed with water, regenerated with 10 percent hydrochloric acid, and washed with distilled water until free of acid. Liquor I (1000 grams) was passed through this resin column, and the column was washed with water. This complete operation was repeated four times, so that a total of 5000 grams of Liquor I was decationized. The combined effluents and washings were concentrated to a volume of 5000 ml. and a weight of 5170 grams. This liquor contained 7.7 grams of total solids per 100 grams of liquor, and the methoxyl content of the solids was 9.48 percent or a total of 37.74 grams of methoxyl. This methoxyl recovery from 38.0 grams in the original Liquor I applied to the column represents a recovery of about 100 percent.

Similarly, Liquor II was decationized by first diluting 300 grams of the concentrated liquor to 1000 ml. and passing the liquor through the column of Amerlite IR–120. Again the process was repeated four times, and the combined effluents and washings were concentrated to a volume of 5000 ml. and a weight of 5145 grams. This liquor contained 10.00 grams of total solids per 100 grams of liquor, and the methoxyl content of the solids was 8.9 percent of a total of 45.8 grams of methoxyl. The loss of 1.8 grams of methoxyl from the original 47.6 grams applied to the column was recovered by alkaline wash.

Literature Cited

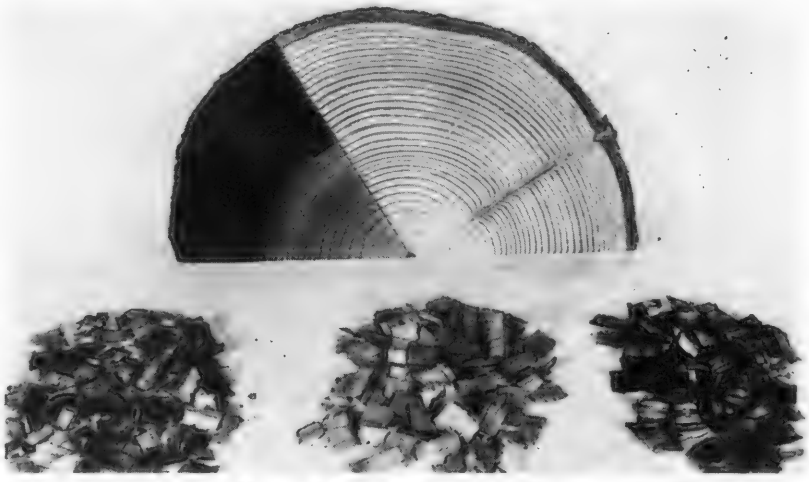
1. Pearl, I. A., and D. L. Beyer. 1957. Tappi 40: 45.
2. Pearl, I. A. 1957. Forest Prod. J. VII (2)88.
3. Van Blaricom, L. E., and K. R. Gray. 1955. U. S. patents 2,710,254 and 2,710,255 (June 7); 1957. Can. Patents 537,334 and 537,335 (Oct. 8).
4. Van Blaricom, L. E., K. R. Gray, and F. G. Ward. 1958. Can. Patent 554,293 (March 11).
5. Stone, J. E., and M. J. Blundell. 1952. Anal. Chem. 23: 771.
6. Pridham, J. B. 1956. Anal. Chem. 28: 1967.
7. Pearl, I. A. 1944. Ind. Eng. Chem. Anal. Ed. 16: 62.
8. Vieböck, F., and H. Schwappach. 1930. Ber. 63: 2818,3207.

HEARTWOOD CONTENT OF

Douglas-Fir Mill Residues[1]

R. M. SAMUELS AND D. W. GLENNIE
Oregon Forest Products Division
Research Center, Corvallis

Chips from veneer trim plus cores contained the most heartwood. Sawtimber heartwood content varied more than expected. A spray indicator identified chips accurately.



Chips and left side of Douglas-fir disc were sprayed liberally with Triplex Indicator (A) Mixed heartwood-sapwood; (B) All heartwood; (C) All sapwood.

CHIPS FROM SAWMILL or veneer mill residues may exhibit a wider range in type and quality than those from whole logs. Since sapwood and heartwood portions of Douglas-fir differ significantly in physical and chemical constitution, it is of interest to know the variation in heartwood content of chips from mill residues.

It is known, for example, that Douglas-fir sapwood may be pulped by the sulfite process about as readily as spruce, but the heartwood is somewhat resistant to sulfite pulping (9, 4)[2]. Recent pulping trials at the Forest Products Research Center on Douglas-fir sapwood and heartwood by the Magnefite process revealed that pre-extraction of heartwood chips with hot water increased the ease of pulping (10). Yields of kraft pulp were found to be lower as the heartwood content of various Douglas-fir specimens increased (2). Also, Douglas-fir sapwood is relatively easy to treat preservatives while the heartwood resists penetration (7, 1).

On the other hand, it has been suggested (5) that the moderate decay resistance of Douglas-fir heartwood may result chiefly from fungicidal toxicity of taxifolin, a heartwood extractive present in much smaller concentration in the sapwood (9, 6, 3). The higher acidity of Douglas-fir heartwood (pH 3.0–4.5) compared to sapwood (pH 4.5–6.8) has an important effect on pulping chemicals and curing time of resin. No gross differences in the nature of lignin in sapwood and heartwood have been found, although appreciable differences may exist (4, 1). Other distinguishing characteristics of sapwood and heartwood in young-growth Douglas-fir have been discussed by Wellwood (11).

Percentage of heartwood in a Douglas-fir log may be computed readily from log dimensions and heartwood diameter. The sapwood-heartwood boundary usually is defined sharply through color contrast, which may be enhanced by a stain (7).

A simple method was devised to spray residue chips with a stain so that mixtures of sapwood and heartwood chips were separated easily, and an estimate made quickly of the percentage of heartwood.

Experimental Procedure

Raw Material: Test material was obtained from an 80-year-old Douglas-fir tree felled in western Linn County, Oregon. The top and bottom 4 feet of the tree were discarded, which left a log 68 feet in length, 5 inches in diameter at the top, and 13 inches at the butt. From the extreme bottom of this log, a pair of ¾-inch discs were removed. The heartwood diameter of one disc (13-inch diameter) was 10.(inches, so the percentage of heartwood by volume was 66.5 percent. The sapwood and heartwood portions of the adjacent matched disc were chipped separately by hand to provide a known mixture of sapwood and heartwood.

Staining: The stain found most useful for measurement of heartwood content in chip samples consisted of a 0.04 percent solution of bromcresol green in 50 percent ethanol. The indicator solution was adjusted to a pH of 7.0 with dilute sodium hydroxide solution. When the indicator was sprayed on a mixture of chips, the sapwood remained green, while the heartwood turned a pale orange to yellow color. Hellige Triplex Indicator (for testing soil pH) also was found to be satisfactory for spraying chips. The same color contrast resulted, although color development appeared more slowly and less distinctly than with the ethanolic solution of bromcresol green.

Test method: The separate portions of sapwood and heartwood from the test discs, after hand-chipping and screening (¼-inch screen), yielded 388 sapwood and 900 heartwood chips. Thus, the percentage by number of heartwood chips of the total was 69.9 percent, a difference of 3.4 percentage points from the measured percentage of heartwood by volume (66.5 percent). The sapwood chips were

The Authors: Robert Samuels holds a BS in chemical engineering from the University of Washington. He was employed by Crown Zellerbach before he joined the Research Center, where he has been in charge of the pulping section since 1955.

Douglas Glennie holds a PhD from the University of Washington in organic chemistry, and was a research assistant at NY State College of Forestry at Syracuse. He is now chief of chemical research at the Research Center.

[1] A contributed paper, received March, 1959.

[2] Numbers in parentheses refer to the Literature Cited at the end of this report.

Table 1.—HEARTWOOD CONTENT OF TEST DISCS

Sample	Sapwood chips	Heartwood chips	Heartwood chips	Heartwood by weight
			%	%
Matched disc			66.5[1]	71.0
Test disc				
(actual)	130	265	67.1[2]	68.7
(sprayed)	145	250	63.3[2]	64.9
(actual)	73	150	67.3[2]	69.3
(sprayed)	73	150	67.3[2]	69.3

[1]Based on volume of matched disc.
[2]Based on number of chips from test disc.

Table 2.—HEARTWOOD CONTENT OF COMMERCIAL DOUGLAS FIR RESIDUE CHIPS

Source	Carload samples	Estimated heartwood content[1] Mean	Range	Remarks
		%	%	
A	12	78.8	64–91	Veneer trim, plus cores
B	7	63.3	58–74	Veneer trim; no cores
C	8	73.5	62–84	Mixed sawmill and veneer residue
D	11	48.8	28–62	Sawmill residue
E	9	69.8	61–89	Sawmill residue
F	4	48.1	41–56	Sawmill residue
G	10	48.6	25–81	Sawmill residue

[1]By weight.

marked with a black spot on one face, then were mixed with the heartwood chips, and a random sample of 395 chips was removed. These were sprayed liberally with Triplex Indicator. After 5 minutes, the chips were arranged randomly in a single layer by one operator such that sapwood chips were placed with the marking spot down.

Another operator separated the chips into two groups on the basis of green (sapwood) and pale-yellow (heartwood) color. The percentage by number of heartwood chips was calculated from a chip count. All chips then were oven-dried and the percentage of heartwood by weight was calculated. Dry chips in each group then were placed with marked faces up, and the number of sapwood and heartwood chips incorrectly grouped was recorded. This procedure was repeated with a second sample of 223 chips. Results are given in Table 1.

From results of similar tests not shown, it was found that heartwood content could be determined closely.

Survey method for commercial chip suppliers: Samples of residue pulp chips from seven sources, which covered a broad geographic area and several types of milling operations, were obtained from a pulp mill. The samples were residual chips from large lots used at the pulp mill for moisture determinations. These large lots were taken by a mechanical sampler during unloading of rail cars of chips, and each lot was considered representative of a 20-unit carload of pulp chips.

Chip samples of about 75 grams oven-dry weight were spread on a glass-topped table and sprayed with one of the indicators described previously. After separation of the heartwood and sapwood chips, both were oven-dried, and percentage of heartwood in the oven-dry weight of chips was calculated. Oven-drying the chips before staining appeared to increase the rate of color development in the stained chips, particularly when the indicator solvent was 50 percent aqueous ethanol. An additional check on the test procedure was made by spraying a 1:1 mixture of heartwood and sapwood chips. The indicated heartwood content was 49.5 percent, an error of less than one percent.

The heartwood content of Douglas-fir chips obtained from a commercial outside storage pile could not be distinguished by the usual spray technique. Apparently, high moisture conditions allowed sufficient diffusion of acidic constitutents to produce uniform pH in both heartwood and sapwood chips. Presumably such heartwood may be distinguished by virtue of water-insoluble constituents to present in sapwood. A test procedure based on this principle has not been devised, but would be valuable for measurements on stored chips. Results for chips from 61 carloads are in Table 2.

Discussion of Survey Results

Young-growth Douglas-fir is reported to contain about 65 percent heartwood, regardless of diameter (8). This value may approximate the overall average for Douglas-fir sawtimber. It may be seen in Table 2 that heartwood content was higher in veneer residue than in sawmill residue. Highest heartwood content was found in residue chips from veneer trim and peeler cores. Heartwood content of veneer chips from a source not including cores was somewhat lower, as expected. Lowest heartwood content was found in sawmill chips from three different sources; these yielded almost identical mean values.

Insufficient samples were taken from each residue source to characterize statistically, by means of standard deviation calculation, the distribution of samples about the mean. Frequency distributions of the samples available did not indicate that distribution was normal for all of these sources. The data indicated that distribution of the heartwood content of residue chips may vary greatly from source to source.

Although factors that influence variation in heartwood content of sawmill residue chips have not been investigated extensively, observations have indicated that slabs are predominately sapwood, and heartwood residue is derived in large part from end-trim. This finding suggests that logs with little defect and requiring only minor trimming would produce residue relatively low in heartwood. Unchipped residue from a gang mill cutting small logs contained little end-trim and a rather low level of heartwood, substantially lower than values from any of the sources in the present survey. Values obtained should be considered illustrative and not necessarily typical.

Where heartwood content in residues is recognized to exert significant influence on the quality of pulp, particle board, or other manufactured product, various measures may be taken to institute a degree of control. First, a method is required for obtaining representative samples of incoming residues to the plant. Second, a technique for estimating heartwood content is required.

Literature Cited

1. Brookbank, E. B., and F. E. Brauns. 1940. The chemical nature of Douglas-fir lignin. Paper Trade J., 110 (5):33.
2. Hammond, R. N. and P. S. Billington. 1949. The relation of kraft pulp qualities to the wood properties of Douglas-fir. Tappi 32:563.
3. Hergert, H. L., and O. Goldschmidt. 1958. Biogensis of heartwood and bark constituents. I. A new taxifolin glucoride. J. Org. Chem. 23:700.
4. Hoge, W. H. 1954. Resistance of Douglas-fir to sulfite pulping. Tappi 37:369.
5. Kennedy, R. W. 1956. Fungicidal toxicity of certain extraneous components of Douglas-fir heartwood. Forest Prod. J., 6(2):80.
6. Kennedy, R. W., and J. W. Wilson. 1956. Variation in taxifolin content of a Douglas-fir stem exhibiting target ring. Forest Prod. J. 6(6):230.
7. Lund, A. E., and M. Sciascia. 1956. A new color indicator for the differentiation of sapwood and heartwood in Douglas-fir. Forest Prod. J. 6(11):483.
8. Paul, B. H. 1950. Quality of second-growth Douglas-fir and suggested means of improvement. Proc. FPRS 4:16–33.
9. Pew, J. C. 1949. Douglas-fir heartwood flavanone. Its properties and influence on sulfite pulping. Tappi 32:39.
10. Samuels, R. M. 1958. Magnefite pulping of Douglas-fir. Forest Prod. J. In Press.
11. Wellwood, R. W. 1955. Sapwood-heartwood relationships in second-growth Douglas-fir. Forest Prod. J. 5-(2):108.

METHODS AND MACHINES FOR

Quality Control for Forest Products[1]

O. J. BLACK[2]
International Business Machines Corp.
Bridgeport, Connecticut

Electronic computations are necessary to take advantage of the multiple regression analysis, a powerful quality control tool. The IBM 650, when properly programmed, solve in minutes otherwise impractical relations.

The IBM 650 in Operation.

THE TECHNIQUES OF statistical quality control are applicable to many areas of forest products research and utilization. Some techniques are computationally simple and can be used to advantage with only manual calculation or the assistance of a desk calculator. Others, however, are burdensome and become virtually impossible to apply to realistic problems without some form of automatic calculation. The latter class includes the powerful and flexible technique of multiple regression analysis, whereby one can determine the quantitative effects of a number of independent variables on one or more dependent variables. The result of such an analysis is an equation that best fits the observed data in a statistical sense, and that can be extremely useful for prediction and control.

The purpose of this paper is to survey briefly the statistical techniques applicable to forest products indicating their utility and computational difficulty and to demonstrate by an example of multiple regression analysis the value of automatic calculation by an intermediate-size electronic computer.

The Author: O. J. Black, Applied Science Representative for IBM, holds BS and MS degrees in mechanical engineering from Cornell Univ. He also holds an MS in mathematics from Fordham Univ.

Historical Development of Statistical Quality Control

In 1654, Pascal and Fermat exchanged correspondence on probabilities in gambling games. This is commonly taken as the birth date of statistics, and it makes statistics one of the younger branches of mathematics. Its systematic application to the control of quality, however, is far more recent than even that date would suggest.

The idea of a "control chart" originated in a memorandum prepared by Dr. Walter Shewhart of the Bell Telephone Laboratories in 1924. In the preceding 270 years, important advances had been made in probability and statistics by mathematicians and other scientists, but this marked the beginning of statistical control of quality of manufactured products[3]. Its logical antecedents were the realization of interchangeable manufacture around 1870, and the development of an adequate theory of sampling in the first part of this century.

Use of the control chart techniqu grew slowly here, more rapidly abroad, until World War II provided an im petus to statistical quality control tha drastically altered its rate of develo ment. The military, faced with th need for countless parts and compo nents that must meet the strictest qual ity standards, adopted statistical qual ity control themselves and sponsored intensive educational programs for representatives of industry. As a result, the control chart was firmly established among the suppliers of military equipment, and also among sub-contractors, job shops, and other peripheral organizations.

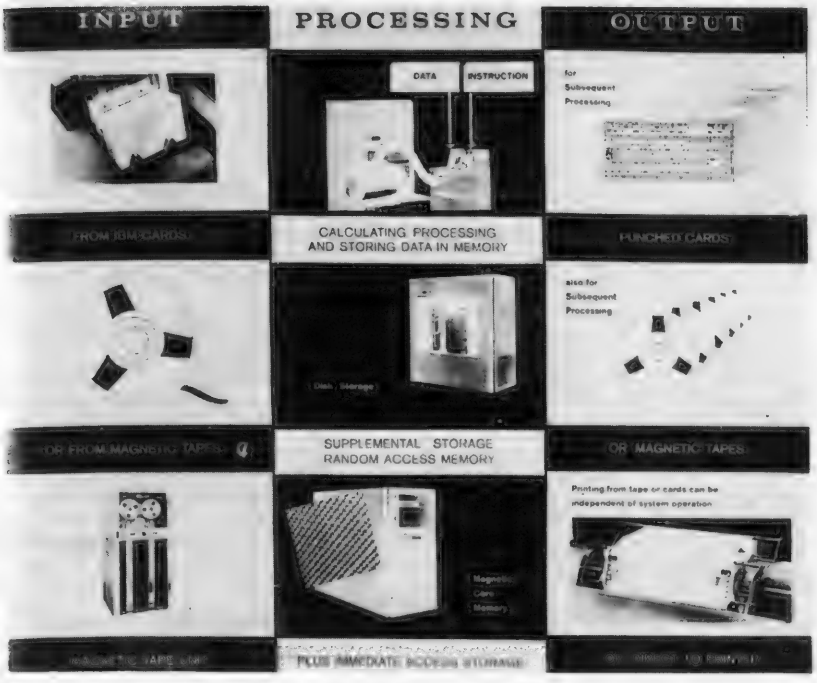
From a wartime concentration in the mechanical industries, statistical quality control techniques have assumed more and more importance in the process industries, notably petroleum and chemicals. The control chart is found today in such unlikely applications as the productivity of sales personnel and the objectivity of subjective testers—those who taste, smell, and so forth. The infusion of statistical methodology through American industry can be assumed to be practically complete, although the benefits derived from it are far from uniform.

This is a brief history of statistical quality control as it relates to manufactured product. There has been a growing realization, however, that a scientific discipline defined only in terms of sampling inspection and acceptance criteria is a narrow one. Increasingly, then, "quality control" is understood as "quality management" which implies a concern with quali

[1] Presented at Session XX, Quality Control, FPRS 13th National Meeting, June 28–July 3, 1959, San Francisco.

[2] Acknowledgement is made to Prof. A. C. Barefoot, School of Forestry, North Carolina State College, for permission to use data from his doctoral thesis at Duke Univ., and to the Esso Research and Engineering Co. for allowing the use of the Esso Stepwise Regression Program.

[3] Shewhart, W. A. 1931. Economic control of quality of manufactured product. Van Nostrand Co., Inc., New York.



Information is fed into and received from the IBM 650 in several ways.

that pervades every apect of the production system, from research, engineering, and fabrication to inspection. In some of these areas, the statistics employed bear no intrinsic relation to manufactured product as such. In fact, some of the applicable techniques in experiment planning and evaluation were pioneered and developed by agricultural workers long before World War II.

Thus a parallel development could be traced past agricultural milestones rather than mechanical ones. The main point, however, is that the wartime and postwar emphasis on statistics in industry has caused searching investigations that have benefited many areas in addition to industry. It has been a matter of ferment in one phase of the economy transferring part of its energy to ferment in another phase, and this procedure continuing and accelerating until finally the total economy itself is being seriously considered on a statistical model.

Areas of Application in Forest Products

Normal and Student "t" Variables: Consider a characteristic, say specific gravity, which is normally distributed with known variance in populations of trees. Suppose the average specific gravity of a given population -yellow poplar of a certain age, for example—is also known. Then if specific gravity were repeatedly measured this population and the measurements averaged, the average specific gravity of the sample would also be normally distributed with known variance. This means that limits could be set, and the sample average would not exceed these limits if only chance sampling fluctuations were operating. Note that these limits could be set for a sample of given size, based on a knowledge of the population average and variance, without the sample being taken.

Suppose now that the population average is not known. Then by measuring specific gravity of a sample, limits could be set above and below the sample average which would include the population average to any desired degree of probability. In a similar way, two samples could be measured and limits set on the two sample averages, to test the hypothesis that the two samples came from the same population.

This is a reasonable problem, and an exceedingly common one, regardless of whether the populations in question are populations of trees, of petroleum fractions, or of piece parts. What makes the approach unrealistic, however, is the assumption that the population variance is known; generally it is not.

To attack the same kind of problem with less knowledge, one uses the statistic $x\sqrt{n-1}/s$, where $\bar{x}$ is the sample average, n is the size of the sample, and s is the square root of the sample (not the population) variance. If the characteristic is normally distributed in the population, then this sample statistic has the Student "t" distribution (named for the pseudonym of its discoverer). Thus limits can be set on the sample average, based on the sample variance, the sample size, and a table of factors found in any statistics text.

Tests of significance can then be made between sample and population or between sample and sample.

Calculations Involved: The calculation of the Student "t" is simple—$\bar{x}$ and s have to be determined; $\bar{x}$ is the arithmetic mean $\frac{1}{n}\Sigma x_i$, and s is the root-mean-square deviation from the mean $\sqrt{\frac{1}{n}\Sigma(\bar{x} - x_i)^2}$. For calculating ease, s is usually represented by the equivalent $\sqrt{\frac{1}{n}\Sigma x^2 - \bar{x}^2}$. Thus the measurements themselves must be summed and divided by n, the squares of the measurements must be summed and divided by n, the average must be squared, and a square root must be taken. Then a table of factors must be consulted.

For small values of n, a desk calculator is entirely adequate. As n increases to 25 or so, one begins to appreciate the ability of a calculator to develop Σx_i and Σx_i^2 at the same time. As the number of samples increases, an automatic square root extraction becomes more valuable. Finally, as n grows as large as 50 to 100 or more, or as the number of samples (with n not necessarily constant) grows to 10 or more, the merits of a desk-size computer make themselves felt. These can be programmed—in advance and once only— to make the calculations automatically on all sets of data. Some can also be used like desk calculators, and as such have advanced features like automatic square root.

Alternatively, if the data are coded in punched cards, as they might be for other reasons, an inexpensive punched-card calculator can be wired for automatic calculation. If a more powerful computer is available, its relatively large memory can be used to store the Student "t" table, and look-up can also be automatic.

The Chi-Square and F Statistics: This review of alternatives applies equally well to other common and useful statistics, such as chi-square and F. Both are essentially ratios of variances, hence the arithmetic involved is the same as outlined above. Chi-square is usually employed to test goodness of fit between hypothesis and sample in the following type of situation: theory predicts tree heights in a second-growth stand to be distributed in a certain way, but in an actual stand they are distributed differently; should the

theory be modified or is the difference due to chance? Chi-square can be calculated and limiting values established that will distinguish between chance and directed effects at the desired level of probability.

The F statistic can be used simply to compare one variance with another, the implication being that the process that produces the larger variance is inferior. This is true of test-method evaluation, for example. But by far the widest use of F is in the technique called analysis of variance, which partitions the total variations in experimental data into components due to each of a number of factors. The test of significance involved compares the variance associated with each factor to the residual or unexplained variance; if the ratio is sufficiently large, the factor is deemed significant.

Design of Experiments: The design of experiments for effective use of analysis of variance can become complex. The experimenter who is in a position to decide what tests he will conduct to test a given hypothesis has a wide range of ingenious, efficient designs to choose from. These begin with the Latin squares and randomized blocks of early agricultural research and continue through Youden squares and the Box–Wilson techniques of steepest ascent[4,5] These designs are accompanied in the texts by well-developed calculation procedures whose arithmetic, as previously mentioned, is simple. An order of complexity is introduced, however, by the number of different bases for computing variance, even in a modest design, and the breakpoint between manual and automatic calculation occurs sooner.

When the problem involves the quantitative effect on some characteristic of a number of factors or treatments, and the experimenter is not free (perhaps for reasons of time) to design his experiment, multiple regression analysis applied to historical data can be of great value. This technique will be discussed in some detail, and the results of its use in a problem involving forest products will be described in subsequent sections.

Fundamentals of Multiple Regression

Simple Linear Regression: Consider the basic regression equation $y = a_o + ax$. In attempting to find the coefficients a_o and a, so that given the independent variable x we will be able to predict the dependent variable y, we assume a certain model in which y and x vary linearly with each other. the coefficients a_o and a for least-squares fit are found without difficulty by solving the simultaneous equations:

$$\Sigma y = na_o + a \Sigma x$$
$$\Sigma xy = a_o \Sigma x + a \Sigma x^2$$

which make use of the sums of the observed x_i and y_i, of their squares and of the products.

In addition to the coefficients that define a prediction equation, a statistic is usually determined that measures how well the straight line so defined fits the observed data. Poor fit could be due to errors of observation, to non-linearity in the relation between x and y, or to an incomplete model. The statistic is called the correlation coefficient r, and it is defined by $r^2 =$

$$\frac{a_o \Sigma y + a\Sigma xy - (\Sigma y)^2/n}{\Sigma y^2 - (\Sigma y)^2/n}$$

It varies from —1 to +1, with $[r] = 1$ signifying perfect correlation or fit in the positive or negative sense ,and 0 signifying complete lack of correlation on this model. A physical significance can be given to r by stating that r^2 equals the percentage of variability in y that is explained by the variation in x. Limiting values of r for different levels of probability are found in several statistics texts[6].

Multiple Linear Regression: Consider now the extension of the model to include more than one independent variable. The regression equation becomes $y = a_o + a_1x_1 + a_2x_2 + a_3x_3 + \ldots$ and for every variable added there is a new coefficient to solve for. This means one more equation in the set of simultaneous equations. Solving sets of simultaneous equations requires a considerable amount of record-keeping, so that one begins to appreciate a fully automatic method of solution at about five equations or four independent variables. The complementary factors of speed and accuracy also favor automatic solutions at this point.

It was stated above that multiple regression analysis is a powerful and flexible technique. The objection is sometimes made that the assumption of a linear model limits its flexibility and power. The objection is valid, but the limitation occurs at a higher level than is commonly supposed. For the model is linear in its coefficients, not in its variables. Moreover, the "independent" variables are not necessarily independent of each other. Hence nothing prevents the experimenter from creating a new variable, say $x_4 = x_3^2$, and using both x_3 and x_4 in the model. The same reasoning applies to other useful transformations such as x^3, $\sin x$, and $\log x$.

Even when coefficients are not linear, the model can sometimes be transformed into a linear one, such as $y = ce^{ax}$ to $\ln y = \ln c + ax$. However, $y = ce^{ax} + de^{bz}$ cannot be so transformed. Finally, the independent variables do not have to be continuous; given a characteristic that occurs in three forms *A*, *B*, and *C*, the analyst can create three variables x_A, x_B, and x_C, which vary in the following way:

Characteristic is A $X_A = 1$ $X_B = 0$ $X_C = 0$
Characteristic is B $X_A = 0$ $X_B = 1$ $X_C = 0$
Characteristic is C $X_A = 0$ $X_B = 0$ $X_C = 1$

All this is not to suggest that proliferating variables is sound practice. Variables "thrown in" without sufficient reason serve only to complicate the model needlessly, and may even obscure the relationship. But when a necessary variable is non-linear or non-continuous, the multiple linear regression technique is flexible enough to include it, after a suitable transformation.

Example of Multiple Linear Regression Analysis

To demonstrate the power of regression analysis and the utility of an electronic computer for performing it, an example will be discussed that involves the relation of 11 characteristics of yellow poplar wood to its toughness. The characteristics are as follows:

1. Age from pith
2. (Age from pith)^2
3. (Age from pith)^3
4. Site index
5. Vessel percentage
6. Height
7. Lignin ratio
8. Ray percentage
9. Gelatinous fibers
10. Thickness of test specimen
11. Width of test specimen

Twenty-five observations of these characteristics, including toughness, are listed in Table 1. These have been selected from a set of 432 observations compiled by A. C. Barefoot for a doctoral thesis at Duke University. Regression analysis of the 12 variables was performed on an IBM 650, an intermediate-size electronic computer, by means of a program prepared by M. A. Efroymson and O. Schricker of Esso Research and Engineering Company.

Stepwise Regression Procedure: This program, called the Esso Stepwise Regression Program, has several distinctive features that make it well suited for this demonstration. It produces a series of regression equations, beginning with the most significant independent variable and adding variables in order of decreasing significance until the remainder are insignificant. It also removes a variable, previously considered significant, when the addition of several other variables makes that

[4] Cochran, W. G., and G. M. Cox. 1957. Experimental designs. John Wiley and Sons, Inc., New York. 2nd Ed.

[5] Davies, O. L. (ed.) 1954. The design and analysis of industrial experiments. Hafner Publishing Co., New York.

[6] Pearson, E. A., and K. R. Bennett. 1942. Statistical methods. John Wiley and Sons, Inc., New York.

one insignificant. Thus the successive regression equations developed from the data of Table 1 are as follows:

1) $T = 4.29$
2) $T = 235.6t - 27.015$
3) $T = 224.5t + 0.0380A - 26.319$
4) $T = 188.1t + 0.0290A - 0.0598H - 20.738$
5) $T = 180.3t + 0.1216A - 0.0692H - 0.0017A^2 - 20.310$
6) $T = 150.6t + 0.1450A - 0.0680H - 0.0021A^2 + 0.0751R^1 - 17.924$
7) $T = 121.3t + 0.1666A - 0.1294H - 0.0023A^2 + 0.1025R^1 + 0.0398I - 18.329$
8) $T = -0.9t + 0.2083A - 0.1145H - 0.0029A^2 + 0.0978R^1 + 0.0486I + 92.0W - 49.159$
9) $T = 0.2081A - 0.1144H - 0.0029A^2 + 0.0977R^1 + 0.0485I + 91.6W - 49.093$
10) $T = 0.4128A - 0.1144H - 0.0113A^2 + 0.1053R^1 + 0.0514I + 87.5W + 0.0001A^3 - 48.455$

Note that the first equation contains on the right side only the average value of toughness. This is the best estimate when no independent variables are considered. The most significant independent variable is thickness of the test specimen, hence the next equation contains only it and a constant on the right side. The next most significant variable is age, followed by height, which has a negative effect on toughness. As the process of adding variables continues, the coefficients of variables previously in the regression change, so that at any stage the coefficients represent the best (least squares) fit of those variables in the regression at that stage.

Note also that at the eighth stage, where width of the test specimen is added, the combined effect of width and the other variables in the regression renders thickness insignificant. Consequently, at the ninth stage thickness is removed. This does not invalidate the selection of thickness at the second stage. If one wanted to describe the variation in toughness by only one independent variable, the best choice would be thickness; thickness and age describe the variation in toughness better than thickness alone, and better than thickness plus any other variable, and so on.

It is significant that the square and the cube of age have been included in a linear regression model. The ability to do this was mentioned previously; the computational procedure considers A^2 and A^3 simply as two additional variables for which linear coefficients are to be found, and the same would be true of e^A or *log H*, for example.

Value of Prediction Equations: With this series of regression equations available, one may ask how useful any one of them is or how much utility is added by including the seven most significant variables rather than six, or six rather than five. Multiple correlation coefficients have not been computed, but instead the program has generated the standard error of estimate at each stage of the regression. These are shown below.

1) $S = 1.71$
2) $S = 1.49$
3) $S = 1.35$
4) $S = 1.30$
5) $S = 1.23$
6) $S = 1.19$
7) $S = 1.14$
8) $S = 1.06$
9) $S = 1.10$
10) $S = 1.04$

Approximate 95 percent confidence limits for predicted values of toughness can be obtained by doubling the standard errors. Thus confidence limits are improved from $\pm$ 3.42 at stage 1, which represents the total variation in toughness, to $\pm$ 2.98 at stage 2 when thickness is introduced, and on to $\pm$ 2.08 at stage 10 when seven independent variables are in the regression. The stage 10 confidence limits represent about $\pm$ 50 percent of the mean, hence the final regression equation is probably not useful for prediction purposes.

Criterion for Significance: The criterion for determining the significance of independent variables is under the control of the analyst. It was purposely set low (somewhat more than 10 percent probability) in this example for purposes of demonstration. At about 5 percent probability, stage 3 would be the last, and would yield the regression equation: $T = 224.5t + 0.038A - 26.319$, with $s = 1.35$, or 95 percent confidence limits $\pm$ 2.70.

Power and Economy of Electronic Computation: The Esso Stepwise Regression Program generates all of the information so far discussed, plus the mean values of all variables considered, their residual sums of squares and cross-products, a complete matrix of partial correlation coefficients, a tabulation of actual versus predicted values, and other useful statistics. Up to 33 independent variables can be used, and several different regressions can be obtained from the same set of data by considering different variables to be dependent in turn.

This procedure can be very economical with respect to time, because the time-consuming portion of the calculation is terminated as soon as the remaining independent variables are insignificant. This is made possible by the 20,000-digit memory of the IBM 650, which makes practical the retention of intermediate results not even transcribed in normal manual procedures. This advantage, of course, is in addition to the speed and accuracy inherent in an electronic digital computer. The entire machine procedure to generate the 10 regression equations and supporting information that have been discussed required less than 15 minutes; for a criterion of 5 percent probability and the associated three stages, 10 minutes were sufficient.

Other Statistical Programs and Systems

A number of other statistical programs and systems are available for the IBM 650 computer through the 650 Program Library[7]. These include correlation and regression analysis, curve fitting, and analysis of variance. Two of them are worthy of particular mention here.

Shell Regression Analysis Program: The Shell Regression Analysis Program covers the same problem area as is discussed above in the example. Given a set of data punched in IBM cards, however, it is possible by means of code punches in supplemental cards to have the program transform each of the variables in any of a number of ways. These transformations include e^x, x^a, *ln x*, *sin x*, $x^{1/2}$, and several others, and each variable may be raised to any power from 0.1 to 9.9. Moreover, variables can be grouped into terms, with any single term the product of as many as five variables raised to various powers. The capabilities of this program are noteworthy because a regression analysis seldom gives a useful equation on the first trial.

The usual course of action is to try linear regression with untransformed variables. Then if the error of estimate is too high another try is made with some variables transformed, and so on, until a useful equation is obtained or it must be concluded that the model is inadequate. Deciding what transformations to make after each trial requires fairly expert knowledge of the physical system being studied. If one knows or can guess how the variables should be changed, a program that makes the changes automatically is extremely useful for a large number of variables or observations.

Case Statistical Interpretive System: The other program should more properly be called a system, for instead of being aimed at a particular kind of problem, such as regression, it enables the analyst to use the computer for statistical problems in general without knowing the programming language or indeed anything about the machine. A simple numerical command will cause the computer to read the data punched in a set of cards, and accumulate all sums of cross-products, sums of squares, and sums of variables. An-

[7] Muller, M. E. 1959. The role of existing computer techniques in statistics and quality control. Industrial Quality Control. XV (9):10.

other will calculate the Student "t" for testing the difference between sample means. Another will generate the Poisson probability function, useful in waiting-line problems. Another will produce a random number. This Statistical Interpretive System, developed at Case Institute of Technology, can be of the greatest utility for a statistical analyst who does not want to learn how to program, or it can save considerable coding time for a skilled programmer engaged in a one-time problem.

More Powerful Systems

Programs similar to the ones described are available also for more powerful computers such as the IBM 704[7]. On such machines, these programs can be expected to run faster, handle more variables, and exhibit even more flexibility. A recent development in this area has been the programming on the 704 of the Box non-linear estimation method, a rigorous technique for problems that involve non-linear coefficients. This was done, in consultation with Dr. G. E. P. Box of Princeton University, by IBM's Mathematics and Applications Department. Another problem area for which the multiple linear regression model is not suitable, that of simultaneous relations between dependent and independent variables, has been successfully attacked by the same department in a program written for the 704. This latter method, the Full Information Method, has important applications in the economic sphere, and may provide the tool necessary to analyze the American economy itself.

Preserving Lumber in Storage

R. J. MILLER[1]

Even in severe Southern climates, bundles of air-dry lumber can be protected from decay for at least 4.5 years by dip treating the bundles in acceptable preservative.

HANDLING AND OUTSIDE STORAGE of lumber in bulk packages has introduced the need for new methods of preventing fungus and insect attack during storage. As yet, procedures adequate to insure the needed protection are not being put into general practice.

Some time ago, the Lumber Control Officer of the U. S. Army Engineer District, St. Lousi Corps of Engineers, which is responsible for procurement of nearly all lumber stored and used by the Dept. of Defense, became quite concerned about the problem of preservation in storage. The Lumber Control Officer realized that, in the event of another defense emergency, a sudden and staggering demand for lumber would again arise. To meet such a demand, or even to carry on an extensive mobilization program, it would be necessary to create large inventories in outdoor as well as indoor areas. Even now, the Corps of Engineers annually purchases millions of board feet of lumber and dimension which it is essential to store properly, although most of it is used relatively soon after it is procured.

In 1951, the Lumber Control Officer decided to initiate studies to determine the best all-around measures for obtaining the required protection in storage. These studies were to be chiefly, but not solely, concerned with long periods of outdoor storage. Prior to the initiation of this Corps-sponsored work, the total effects of long outdoor storage periods under differing circumstances were not known. Available authentic records covering actual storage for any appreciable time were virtually non-existent. The project was unique, and no proved procedures existed.

Approach to the Problem

The Timber Engineering Company Wood Products Laboratory of Washington, D. C., was engaged to study the entire problem, develop the best preparations and procedures for practical use, and present recommendations, along with the findings, in readily useable charts and guides.

The work was started early in 1951 with a nationwide survey of then-current practices that affect wood products in storage at military storage yards. Upon completion of the survey, laboratory tests designed to yield preliminary information on pertinent questions were carried out. Both accelerated and long-period tests were included in that work. At the conclusion of the laboratory phase, field studies were initiated in November, 1952, at several military installations representing climatic condition throughout the United States.

Since it was so desirable to handle and store lumber in unitized packages, and since conditions favoring fungus and insect attack are particularly prevalent in packages in some climates, the inclusion in the studies of procedures involving preservative treatment in packages was considered essential. This consideration raised questions about the practicability and economic feasibility of adequately treating lumber in packaged form. Satisfactory preservatives, treating procedures, and treating times had to be worked out.

In both the laboratory and field studies, the separate influences of a number of variables were investigated. In addition to treating solutions and treating procedures, other variables included were species of wood, moisture content of the wood when put in storage, and type of piles.

Field tests are still being continued at some of the installations. Knowledge already gained was sufficiently complete by the end of 1955, however, to allow the compilation of a storage recommendation chart and a handbook on the preservative treatment of lum-

The Author: Robert Miller did this work as a wood technologist for TECO. He is presently a consultant to the Architectural Standards Division of the Federal Housing Administration.

[1] Neither the author nor the Corps of Engineers wish to imply that the principal storage measures described are as satisfactory as inside storage or generally accepted practices of stickering, sloping, and so forth. The paper deals with circumstances of manpower, storage facilities, and military experience, which preclude or make highly impractical the use of standard storage practices.

Fig. 1.—Establishing the study on preservation of lumber in storage at Granite City, Illinois

Fig. 2.—A bundle of lumber suspended in the dipping rig over the tank of treating solution.

ber and fabricated products for storage. Revisions of the chart and handbook based on later field data have recently been completed. It should not be construed that recommendations made in the referenced chart for the immersion treatment of wood products to be stored are in any way intended to displace or conflict with recommendations made by the American Wood Preservers Association or others for the pressure treatment of wood to be put into use.

Establishment of Field Tests

By means of handling methods and types of piles both typical of an unlike those encountered at military storage yards, a variety of lumber storage test piles were established in five widely separated installations, each representative of a different climate. The specific locations chosen and the test initiation dates were as follows: (1) Granite City, Illinois, December, 1952; (2) Norfolk, Virginia, January, 1953; (3) Anniston, Alabama, February, 1953; (4) Benicia, California, April, 1953; and (5) Ogden, Utah, May, 1953.

Among the species used at the various test installations were Douglas-fir, white fir, sap gum, ponderosa pine, red oak, western hemlock, southern pine, and cottonwood.

In three of the five test regions, both air dry (19 percent or below) and shipping dry (60–80 percent) lumber was included.

Preservatives used in the work were of two types: water-borne and oil-borne. Specifically, the water-borne preservatives were (1) a solution containing 0.59 percent sodium pentachlorophenate, 0.03 percent sodium salts of other chlorophenols, 0.77 per cent borax, 0.0007 percent ethyl mercury phosphate, and 0.26 percent inert ingredients; (2) a 5 percent solution of a mixture containing 34 percent sodium fluoride, 34 percent potassium bichromate, 25 percent sodium arsenate, and 7 percent dinitrophenol; and (3) a 12 percent solution of a mixture containing approximately the following percentages: 50 percent copper sulfate, 47.5 percent sodium dichromate, and 1.68 percent chromic acid (calculated as equivalent to 2.5 per cent $Na_2Cr_2O_7 \cdot 2H_2O$.

The oil-borne preservatives used were (1) a 1 percent (copper as metal) solution of copper napthenate; (2) a 5 percent solution of zinc alkyl aryl sulphonate; (3) a 0.18 percent (copper as metal-solution of copper-8-quinolinolate; (4) a 5 percent solution of pentachlorophenol; (5) a 5 per cent solution of pentachlorophenol containing water-repellent solids; and (6) a 1 percent (zinc as metal) solution of zinc-8-quinolinolate. No. 1 fuel oil was the solvent for the oil-borne preservatives, except for (5) and (6), which contained mineral spirits.

A total of 159,600 board feet of lumber, including untreated control material, was used in the studies.

Fig. 3a.—Typical surface coverage, essentially complete, in bundles dipped in an oil-borne preservative.

Fig. 3b.—Typical surface coverage in bundles dipped in a water-borne preservative, uncovered areas have been outlined for clarity.

With only one exception, the lumber was 1 by 6 inches by 8 feet, S4S.

To determine whether or not treatment would check deterioration in lumber infected before treatment, one pile of lumber containing medium to heavy stain was included in the tests at Anniston, Alabama. None of the other lumber contained more than very light stain in a few boards.

The test piles were placed in the open in areas fully exposed to the weather from all directions and covered with individual pile roofs.

Fig. 1 shows the two general types of piles established (bulk bundles and pitched, stickered ricks).

About 5 percent of the boards in each bundle or rick were chosen as moisture-content-sample boards. These boards were later used to get indications of moisture-content change. An additional 10 percent of the boards were initially selected as rating-sample boards so that the incidence of stain, mold, decay, and insect damage could be ascertained periodically. Both moisture-content-sample and rating-sample boards were distributed in the units in a predetermined pattern and identified.

Preservative Treatment

A collapsible aluminum tank, 4 by 4 by 12 feet, was assembled at each test installation. Rules were fastened to the inside of the tank so the level of the solution could be read before and after any given quantity of lumber was dipped. The capacity of the tank per unit of depth and the capacities for the various depths within the operating range were calculated and recorded. Thus, absorption in any given quantity of lumber could be readily determined.

The rig used to dip the bundles was designed for use with either a crane or a fork-lift truck. Fig. 2 shows a bundle suspended in the dipping rig and being lowered into the tank with a fork lift. Distribution of the moisture-content and rating-sample boards may be seen.

A 10-minute dipping interval was used for all bundles.

During the treating operations, a number of bundles treated in oil-borne preservatives and a number treated in water-bornes were opened 8 hours after they were dipped for inspection of the surface coverage of the boards. Bundles thus inspected had been dipped in solutions characterized by a vivid natural or artificial color.

Inspection Periods and Procedures

The first inspection at each test installation was made 6 months after establishment of the tests. The second inspection was made six months later and the third, one year after the second. Studies at the Illinois and Utah locations were discontinued at the end of two years, since an appreciable amount of the needed data had been obtained. Tests at the three other locations are still in progress. The last inspection was held at these latter sites in August and September, 1957.

At each inspection, bundles and ricks were opened and each moisture-content-sample board was weighed. Each rating-sample board was rated for the incidence of stain, mold, decay, and insect damage.

To rate a board for the quantity of decay present, both sides of the board were examined and the sum of the non-overlapping lengths that contained decay (as a percentage of the total length of the board) was taken as the decay rating for the board. Only decay far enough advanced to be unmistakably recognized visually was considered (that is, decay characterized by definite zone lines, definite softness of the wood, or mycelial growth).

To rate a board for the degree and quantity of stain, for mold and for bright length, only the top side of the board was examined. Only the portion of the board's length apparently not affected by decay was considered. Stain was rated as percent light stain, percent medium stain, and percent heavy stain.[2]

Results

In general, surface coverage of the bundles dipped in oil-borne preservatives was very good—almost 100 per cent. Coverage with the water-borne preservatives was considerably less complete in this initial work. The relative degrees of coverage obtained may be seen in Fig. 3a and 3b. Modified treating procedures developed in later work gave entirely satisfactory coverage results with the water-borne preservatives.

Absorptions of the various preservatives in the different species of lumber studied and preservative costs, based on prices quoted at the time the work was initiated, are shown in Table 1.

At the Ogden, Utah, test site, where all lumber was initially air-dry, no decay or insect damage was found in any of the test piles—treated or untreated—at the end of the 2-year duration of the tests. Relatively little stain had occurred and, of that which had, essentially none could be rated as heavy.

The situation was quite different at the Granite City, Illinois, test site (where lumber was also initially air-dry) even though the two years in which the studies were made constituted an exceptionally dry period. At the time of the first (6 months) inspection, all bundles of the untreated control piles of the five species of lumber under test contained boards with visible decay in more or less advanced degree. Untreated red oak put up in a stickered, sloped stack was an exception. No decay was found in it. Lyctus beetles were very active in one bundle of untreated oak.

In the untreated piles, decay percentages had increased notably—particularly in the more susceptible species—by the end of the first year of storage. By the end of the second year as high as 20 percent decay was recorded for some untreated piles. After the 2-year period, 3 percent decay was found in the pile treated with the zinc containing preservative, and 1 percent was found in the lumber treated with the anti-stain compound. Essentially no decay was found in any of the other treated stacks. No evidence of insect attack was found in any of the treated material.

The preservatives used at Granite City varied in effectiveness against fungus staining. Over the 2-year period, none of the chemicals completely prohibited the development of stain, but one in particular (sodium fluoride, potassium bichromate, sodium arsenate and dinitrophenol) noticeably inhibited blue stain.

It is interesting to note that the composition just referred to was effective against both decay and stain even though its coverage of the board surfaces within the bulk bundles had been incomplete. For this reason, and because of the cost advantage of some of the water-borne preservatives, later work was done on modification of treating procedures to obtain better surface coverage with the water-borne preservatives and on development of optimum treating times for both water- and oil-borne preservatives. In the later work, the objectives were accomplished.

The last examination of material in test in the three climatic regions where studies are continuing was made in August and September, 1957, about 4-½ years after initiation of the work. The condition of the test lumber at that time is shown for two of those regions in Tables 2 and 3.

At Hampton Roads, Virginia (Table 2), untreated controls for lumber air-dry at the time of storage in bulk bundles were 50 percent decayed after 24 months of storage and 10 percent decayed after 55 months. By contrast, decay was completely ex

[2] As the degrees of stain are defined in the grading rules of the various lumber manufacturers association.

TABLE 1--Absorptions and costs of preservatives used in treating lumber.

Situation number	Pile symbol 1/	Species	Moisture condition	Preservative	Amount of lumber treated	Average absorption per M bd ft	Cost of preservatives per gallon 2/	Cost of preservatives per M bd ft of lumber treated
					Board feet	Gallons	Dollars	Dollars
1	YSP	Southern pine	Air dry	Pentachlorophenol	8208	18.1	.22	3.98
2	YSP 3/	Southern pine	Air dry	Pentachlorophenol	2736	7.6	.22	1.67
3	YSW	Southern pine	Air dry	A water-borne mixture	2736	--- 4/	.195	--
4	YSW 5/	Southern pine	Air dry	A water-borne mixture	2736	10.3	.195	2.01
5	YSC	Southern pine	Air dry	Copper naphthenate	2736	13.8	.40	5.52
6	YSI	Southern pine	Air dry	Copper-8-quinolinolate	5472	13.1	1.40	18.34
7	YSCe 5/	Southern pine	Air dry	A water-borne mixture	2736	11.0	.72	7.92
8	YSA 5/	Southern pine	Air dry	A water-borne mixture	2736	6.9	.035	.24
9	JSP	Southern pine	Shipping dry	Pentachlorophenol	8208	10.0	.22	2.20
10	JSW 5/	Southern pine	Shipping dry	A water-borne mixture	2736	11.0	.195	2.15
11	JSI	Southern pine	Shipping dry	Copper-8-quinolinolate	2736	9.7	1.40	13.58
.2	JSA 5/	Southern pine	Shipping dry	A water-borne mixture	2736	8.3	.035	.29
13	YOP	Red oak	Air dry	Pentachlorophenol	5472	11.4	.22	2.51
14	YOW	Red oak	Air dry	A water-borne mixture	2736	-- 4/	.195	--
15	YDP	Douglas fir	Air dry	Pentachlorophenol	2736	6.9	.22	1.52
16	YDC	Douglas fir	Air dry	Copper naphthenate	2736	10.4	.40	4.16
17	YDA	Douglas fir	Air dry	A water-borne mixture	2736	6.9 6/	.035	.24
18	YDH	Douglas fir	Air dry	Zinc alkyl aryl sulfonate	2736	10.3	.78	8.03
19	YDR	Douglas fir	Air dry	Pentachlorophenol w.r.	2736	9.6	.40	3.84
20	YDHA	Douglas fir	Air dry	Zinc-8-quinolinolate w.r.	2736	6.9	--	--
21	JDP	Douglas fir	Shipping dry	Pentachlorophenol	2736	11.0	.22	2.42
22	YNP	Ponderosa pine	Air dry	Pentachlorophenol	2736	8.3	.22	1.83
23	YNC	Ponderosa pine	Air dry	Copper naphthenate	2736	15.9	.40	6.36
24	YNA	Ponderosa pine	Air dry	A water-borne mixture	2736	15.2 6/	.035	.52
25	YNH	Ponderosa pine	Air dry	Zinc alkyl aryl sulfonate	2736	22.8	.78	17.78
26	YNR	Ponderosa pine	Air dry	Pentachlorophenol w.r.	2736	8.3	.40	3.32
27	YTP	Cottonwood	Air dry	Pentachlorophenol	2736	27.6	.22	6.07
28	YGP	Sap gum	Air dry	Pentachlorophenol	2736	10.4	.22	2.29
29	YFP	White fir	Air dry	Pentachlorophenol	2736	13.9	.22	3.06
30	YFI	White fir	Air dry	Copper-8-quinolinolate	2736	14.8	1.40	20.72
31	YQP	Western hemlock	Air dry	Pentachlorophenol	2736	13.1	.22	2.88
32	YQR	Western hemlock	Air dry	Pentachlorophenol w.r.	2736	9.6	.40	3.84

1. Legend: Original moisture condition of the lumber -
   J = Shipping dry (60-80 per cent)
   Y = Air dry (19 per cent or below)

   Preservatives -
   A = Anti-stain chemical, 1.65 per cent solution of a mixture of sodium pentachlorophenate etyl mercury phosphate and borax
   C = Copper naphthenate (1% of copper metal by wt.)
   H = A 5% solution of zinc alkyl aryl sulphonate
   I = A 0.18% (copper) solution of copper-8-quinolinolate

   Species -
   D = Douglas-fir
   F = White fir
   G = Sap gum
   N = Ponderosa pine
   O = Red oak
   Q = Western hemlock
   S = Southern pine
   T = Cottonwood

   Preservatives -
   P = A 5% solution of pentachlorophenol
   R = A 5% solution of pentachlorophenol containing water-repellent ingredients
   U = Untreated
   W = A 5% solution of a mixture of sodium fluoride, potassium bichromate, sodium arsenate and dinitrophenol
   Ce = A 12% solution of a mixture of copper sulfate and sodium dichromate
   HA = A 6% solution of zinc-8-quinolinolate and octoate (1% zinc as metal)
2. All prices shown are f.o.b. shipping point and are those quoted for large quantity commercial shipments. (Tank car quantities for solutions and carload lots of drums for the dry ingredients for the water-borne mixtures)
3. Boards in the bundles of this pile were 2" x 6" x 8' in size.
4. No absorption data were obtained in these two situations because bundles were re-dipped one or more times in an attempt to get better surface coverage.
5. Boards in the bundles of these piles were dipped singly for 1 minute each.
6. These absorptions were obtained in a 15 rather than a 10-minute dip.

cluded in originally air-dry lumber for the full 55-month period by four of the preservatives used. The other two preservatives greatly limited the incidence of decay for the full period. There can be no doubt as to the financial desirability of treatment in climates similar to Hampton Roads.

Untreated controls for lumber shipping dry (60–80 percent) at the time of storage in bulk bundles were 100 percent decayed by or before the end of the first 6 months of storage. On the other hand, decay was entirely prevented in shipping-dry lumber for 55 months by one of the preservative solutions used (W) and was held to a low maximum (6 percent) by another solution (P). Only one of the other preservatives used on air-dry lumber (A) was used on shipping-dry lumber. This latter preservative was also effective in controlling decay in shipping-dry lumber, but not so effective as preservative P.

It is considered important that, of the preservatives that most effectively controlled decay, preservative W, without qualification, was most efficient against stain.

With respect to the moisture content of the test lumber at Hampton Roads, it is perhaps significant to note some differences between water-borne and oil-borne preservative-treated lumber. In all but one instance, lumber treated in a water-borne salt exhibited a lower (in one instance, the same) moisture content after 55 months of storage than did lumber treated in the oil solutions. This situation existed irrespective of the initial moisture content of the lumber before it was treated.

At Anniston, Alabama, (Table 3), bright, untreated shipping-dry pine had completely deteriorated as a result of decay by or before the end of 12 months of storage. Treated, shipping-dry pine, however, even some with originally stained boards, contained relatively low percentages of decay after 55 months of storage. Although storage of wet lumber in bulk bundles is not recommended, it can be seen from the foregoing that, should such storage be required at any time, losses due to decay could be greatly reduced through the treatments described.

In both pine and gum lumber that was air dry when treated and stacked, decay was completely prevented for the 55-month period by the pentachlorophenol treatment. Only 3 percent decay developed in the bundles treated with copper-8-quinolinolate. By contrast, 18 percent of the dry, untreated pine and 22 percent of the dry, untreated gum had decayed over the full period.

With respect to shipping-dry pine, stain progressed to a considerably greater extent in the pentachlorophenol treated lumber than in that treated with copper-8-quinolinolate. The same trend was apparent in the air-dry pine.

At the time of the last (55-month) inspection very few moisture content sample boards were above 20 per cent moisture content even in piles of lumber initially shipping dry. In earlier inspections, moisture content had been found to be quite high in the initially air dry as well as the initially shipping dry lumber. For example, a year after the tests were established, from 40 to 50 per cent of the moisture content sample boards in the initially air dry piles were over 20 per cent in moisture content, and many these boards were in a 30 to 70 per cent moisture content range.

Moisture contents were taken with an electrical resistance type meter at the start of the experiments. Weights of the moisture sample boards were taken at the same time. Moisture sample boards in the treated bundles were taken again a few hours after treatment. When the periodic inspections were made, moisture contents for the untreated and the oil-borne preservative treated lumber were determined with the meter. For the water-borne treated lumber moisture contents were calculated from the original weights and moisture contents and weights taken at the inspections.

During the first year of the tests at Anniston the total precipitation (52 inches) was about equal to the mean annual precipitation as determined from long-time climatological records. During the second, third and fourth years of the tests total annual precipitation was below normal but was considerable (36, 48 and 44 inches, respectively). During the eight-month period prior to the 55-month inspection precipitation was about normal.

Between the 24- and the 52-month inspections at the Benicia, Calif., test installation, decay increased in the shipping-dry, untreated Douglas-fir lumber from a 15 percent to a 20 per cent level. For the first time (at the 52-month inspection), a trace of decay was found in the shipping-dry, pentachlorophenol-treated Douglas-fir.

During the interval between the two inspections, decay had also started in air-dry, untreated white fir and in air-dry, untreated western hemlock. No decay was present in any of the initially air-dry, treated lumber.

While a considerable amount of light and medium stain developed in the untreated lumber at Benicia, stain was satisfactorily limited in all treated piles.

Conclusions

1. In climates similar to that at Ogden, Utah, initially air-dry lumber can be safely stored outside in bulk bundles indefinitely without the need for preservative treatment.

Table 2-- Condition of treated and untreated southern pine lumber after 55 months of outside storage on the East Coast (Hampton Roads, Va.) 1/

Pile No.	Initial moisture conditions 2/	Preservative 3/	Piling	Decay	Clear	Stain			Mold	Moisture content sample boards above 20% 4/
						Light	Medium	Heavy		
				Percent	Percent	%	%	%	%	Percent
1	Shipping dry	P	Bulk	6	0	0	63	31	0	78
2	Air dry	P	Bulk	0	0	0	100	Trace	0	59
3	Air dry	C	Bulk	1	3	4	93	Trace	0	74
4	Air dry	I	Bulk	0	55	0	45	0	0	22
5	Air dry	None	Bulk	100	0	-	-	-	-	-
6	Shipping dry	None	Bulk	100 5/	0	-	-	-	-	-
7	Air dry	W	Bulk	0	99	0	1	0	0	6
8	Shipping dry	W	Bulk	0	8	0	80	12	0	15
9	Air dry	Ce	Bulk	0	0	0	100	0	0	6
10	Air dry	A	Bulk	4	0	0	77	19	0	96
11	Shipping dry	A	Bulk	15	0	Trace	70	15	0	22
12	Air dry	P	Stickered	0	- 6/	-6/	-6/	-6/	0	-6
13	Air dry	None	Stickered	0	-6/	-6/	-6/	-6/	0	-6

1. Condition ratings shown are pile averages.
2. "Shipping dry" indicates a moisture content of 60-80%; "air-dry" indicates a moisture content under 20%.
3. A = A mixture of sodium pentachlorophenate, borax and ethyl mercury phosphate. Boards dipped singly for 1 minute each. C = Copper naphthenate (1 percent copper by weight). Bulk bundle dipped. I = A 0.18% (copper) solution of copper-8-quinolinolate. Bulk bundle dipped. P = A 5% solution of pentachlorophenol in a No. 1 fuel oil. Bulk bundle dipped. Ce = a 12% solution of copper sulfate and sodium dichromate. Boards dipped singly for 1 minute each. W = A 5% solution of a mixture of sodium fluoride, potassium bichromate, sodium arsenate and dinitrophenol. Boards dipped singly for 1 minute each.
4. Each bundle contains 9 moisture content sample boards; i.e., 27 per pile
5. Rated as 100% decay at the 6-month inspection period.
6. Lumber not rated on this inspection because piles had been blown over and lumber mixed.

Table 3-- Condition of treated and untreated lumber after 55 months of outside storage in the Gulf Coast Area (Anniston, Alabama) 1/

Pile No.	Species	Initial moisture condition 2/	Preservative treatment 3/	Decay	Clear	Stain			Mold	Insect damage
						Light	Medium	Heavy		
				%	%	%	%	%	%	%
1	S. yellow pine	Air dry	Untreated (bulk) 4/	18	66	1	15	Trace	0	0
2	S. yellow pine	Air dry	P (bulk)	0	55	4	41	Trace	0	0
3	S. yellow pine	Air dry	I (bulk)	3	82	Trace	15	0	0	Trace
4	S. yellow pine	Shipping dry	Untreated (bulk)	100 5/	0	-	-	-	-	-
5	S. yellow pine	Shipping dry	P (bulk)	14	6	7	71	2	0	0
6	S. yellow pine	Shipping dry	I (bulk)	20	31	3	46	0	0	0
7	S. yellow pine	Shipping dry	P (bulk)	14	0	0	76	10	0	Trace
8	S. yellow pine 2"x6"x8'	Air dry	P (bulk)	0	80	2	17	1	0	0
9	Sap red gum	Air dry	Untreated (bulk)	22	57	1	20	Trace	0	0
10	Sap red gum	Air dry	P (bulk)	0	94	0	6	0	0	0
11	S. yellow pine	Air dry	Untreated (stickered)	0	51	4	38 6/	7	0	0

1. Conditions ratings shown are pile averages.
2. "Air dry" indicates a moisture content under 20 percent; "shipping dry" indicates a 60-80% moisture content.
3. I = A 0.18% (copper) solution of copper-8-quinolinolate; P = A 5% solution of pentachlorophenol in a No. 1 fuel oil.
4. The term "bulk" is used to indicate that the lumber was dipped and/or stored in bulk bundles.
5. Rated as 100 percent decay at the 12-month inspection period.
6. Most of the stain in this pile was in the outside boards and in the sticker areas.

2. In climates similar to that at Hampton Roads, Virginia, and Anniston, Alabama, initially air-dry lumber can be kept essentially free of decay for at least 4-½ years in bulk bundle storage by dip-treating the bundles in an acceptable preservative solution prior to storage. Sizeable losses from decay can be expected in untreated lumber in much less time.

3. In lumber initially shipping dry (60–80 percent), decay can be greatly limited over a storage period of at least 4-½ years, if the bundles are dip-treated in an acceptable preservative prior to storage. This limitation can be achieved even in cilmates as severe as those at Hampton Roads and Anniston.

4. A 5 percent solution of a mixture of sodium fluoride, potassium bichromate, sodium arsenate, and dinitrophenol (water solvent) is considerably more effective in controlling fungus stain in bulk-bundled lumber stored outside than any other formula.

Summary

In November, 1952, field studies pertaining to the preservation of lumber in storage were initiated at five widely separated military installations, each representative of a different climate. Among the variables used in the work in addition to cilmate, were species of wood, moisture content, type of piles, treating solutions, and treating procedures.

In tests still continuing, initially air-dry, bulk-bundled lumber has been completely protected against decay for 4-½ years in outside storage in climates very unfavorable for storage. This protection has been provided by short-interval dip treatments of the bundles in any of several formulations.

One of the preservatives used has completely excluded decay in shipping-dry lumber (60–80 percent) for a 4-½ year storage period in the most unfavorable storage region. Another preservative has sharply limited decay for the full period. Untreated, shipping-dry controls were 100 percent decayed well within a 12-month period.

Stain has been controlled very effectively by the same preservative that has entirely excluded decay in shipping-dry lumber and under the most adverse climatic conditions. Other preservatives have checked the development of stain to a lesser extent.

MANAGEMENT'S DECISION:

Automate the Sawmill?[1]

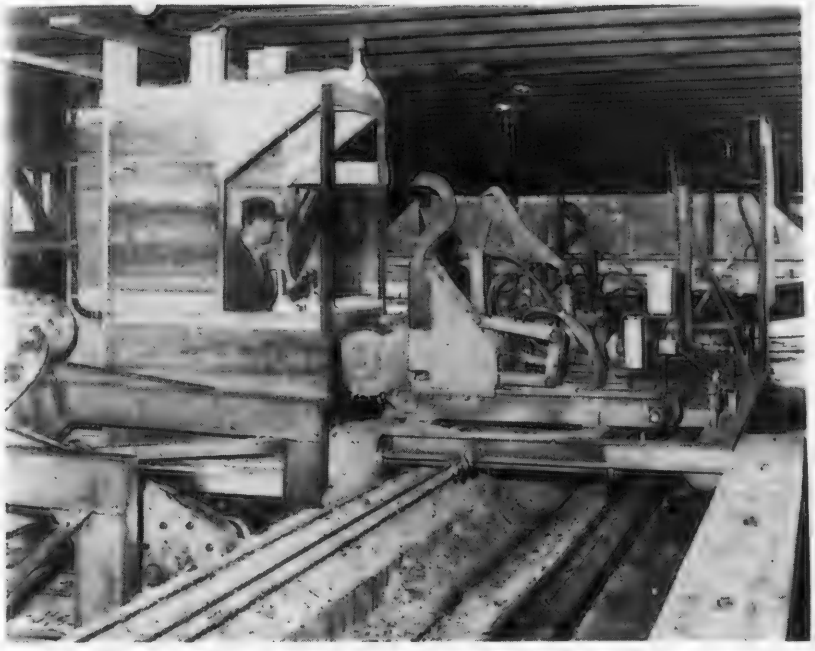


Fig. 1.—The sawyer is an important figure in the automated sawmill. New controls and feed-back application enable the sawyer to do jobs easily on the carriage that once required muscles.

M. H. Mater

President, Mater Machine Works, Corvallis, Ore.

Automation is not merely buying new equipment; combining, reshuffling, adding a few limit switches may give spectacular improvements. Ideas described are practical and working.

Automation has grown so rapidly as an industrial force that many people are not quite sure what it is. A definition of automation that has been pretty well adopted by industry is: *automation is the control of machines by other machines.* For example, (see Fig. 3) if two men are rolling logs on to the log deck and then onto the carriage, it is manual labor. Now suppose these men are replaced with a live chain deck, a log stop and loader, and a log turner, and only one man is used on the deck, where he pushes buttons to control the flow of logs to the carriage. This is *mechanization.* Finally, if a machine is installed to control the live deck and stop and loader, so that the logs move toward the carriage automatically, thereby replacing the man who pushed the buttons, you have *automation.*

Mechanization and automation do not consist merely of installing new machinery. Often new machinery isn't required. Mechanization and automation may be considered to be *new ways of thinking.* The sawmill operator who asks himself: "What are my opportunities for increasing production per unit of labor in my mill?" is thinking automation. Note that he did not say: "What new machinery should I put in to my mill?" Installing new machinery in a mill does not necessarily save labor or increase efficiency. For instance, if an operator has an old, two-man carriage in his mill, with a dogger and setter, and replaces it with a *new* two-man carriage, he may save maintenance money and manufacture better lumber, but he will not increase productivity or efficiency.

On the other hand, sometimes—in fact, often—production will be increased by "converting" equipment to mechanized or automated operation. For instance, our organization does a land-office business in adding air dogs to old but sturdy carriages and converting them to remote control. If the owner then buys a new carriage later, these conversion items fit right on them and no money is lost on machinery by the mill owner.

Sometimes Automation can be Accomplished by Reshuffling Machinery

New machinery, or converting old machinery, isn't always the road to automation. Sometimes an inexpensive reshuffling of the existing machinery or the addition of a few limit switches can replace a man with a machine and improve productivity. Sometimes a combination of one or two new improved machines, plus a reshuffling of existing equipment and the addition of a few limit switches, gives spectacular improvements.

An example of improving mill productivity with a minimum of new machines was the job done for Oval Wood Dish Co., and old hardwood mill built in 1916 at Tupper Lake, New York. By changing the line of lumber flow, reshuffling positions, and adding only two new pieces of equipment—a riderless carriage and an automation trimmer—the productivity was increased by 50 percent, 7 men were taken out of the sawmill, and sufficient space was saved for the addition of a green chain and lumber storage area.

Another example of reshuffling machinery is a job by Mater Machine Works last year for a "cut-up" plant in a western furniture factory. Six men were taken out of a crew of 24 by reshuffling existing machines and conveyorizing. It is surprising how little it cost to replace these men: just a little over $10,000, less than $2,000 per man!

The Author: Milton Mater holds a B.S. in chanical engineering. He is head also of ater Engineering, sawmill consultants, and is airman of FPRS's Lumber Manufacturing vision.

[1] Presented at the Fall Meeting of the Upper Mississippi Valley Section, FPRS, Oct. 3, 1958.

Fig. 2.—An automated sawmill. Automation does not necessarily mean putting in new equipment or converting old machinery. Sometimes an inexpensive reshuffling of the existing machinery or the addition of a few limit switches can improve productivity.

Judgment and know how are required before tackling reshuffling jobs like these. When you first look into an old mill with lineshafts and belts running all over the basement, and the upper floor full of transfers and roll cases your first feeling is: "Let's set a match to it and start all over again!" But there is a lot of money represented by existing building and existing machinery, which represents a huge capital investment in terms of modern dollars. So in contemplating a changeover, the first thought should always be: How can we improve the efficiency of this operation with the least basic changes? For instance, in one mill the slasher, could have been eliminated, but the slasher was set up so that the pieces of slab wood fell into a conveyor and went into truck loading bins built into the side of the building. All of this equipment would have to have been moved and rebuilt. Such a large expenditure would have been required to move and rebuild that the slasher was left in place. The second question asked is: How much of the old machinery and equipment can we use in the new plans? Can it be modified to do the job required in the new plan? How much will the modernization cost? Will it be less expensive to buy a new machine?

Know-How Is Important In Accomplishing Automation Miracles

The part know-how and imagination can play in accomplishing some of the spectacular miracles of automation has not yet really begun to be appreciated by the sawmill industry. It represents a new way of thinking.

An old truck driver once complained about the pace of modern life. "When we had horses and wagons," he said, "you had to take things easier". "After the horses pulled a load up the hill, you had to walk them a while until they got back their wind. When you delivered a load to a warehouse, you had to wait until the horses were rested before you started back. Now with these trucks everything is too business like. You gas them up every night and you run all day. You never stop to rest, and you no sooner arrive at the warehouse when you're turned around to go back. It's inhuman".

Our sawmills are designed and geared to manual labor, but they must become more "inhuman" in this age of automation. We must accept the concept that material must move *faster* than a man can walk or than a man can handle. We must accept the idea that we have great forces at our control in our machinery, and that we can build controls that can *think* and *react* faster than man.

Automation and Quality Are Compatible

Quality of lumber is very important in a fine-quality hardwood operation. Can automated equipment give finished products of high quality? The answer is yes!

The newer setworks on carriages, for instance, are more accurate than ever. Pre-sets for edgers and trimmers are very accurate, more accurate and consistent than a man.

How to Apply Automation to Your Own Mill

Now you may be thinking to yourself, "What do I need to do in my operation to benefit from automation?" A chart called "Automation Potential" should help you determine this. The chart permits you to make a comparison of your own mill with a highly automated mill—actual existing, operating, practical sawmills. The chart has two columns: On the left-hand side is *Position;* on the right-hand column is *Number of men in an automated mill.* Compare this figure with the Number of men doing the same job *in your mill.* This list is based on actual mills in all species with which Mater has worked.

Position	Number of Men in Automated Mill
Dry log storage, including some species sorting	1
Log deck	0
Sawmill carriage	0
Offbearer	0 except in certain conditions
Edger	1
Edger tailer	0
Trimmer	1
Resaw (mills over 25 M)	splitting only, 0 to 1 man merry-go-round, 2 men
sashgang (mills over 25 M)	2

How do these figures compare with yours?

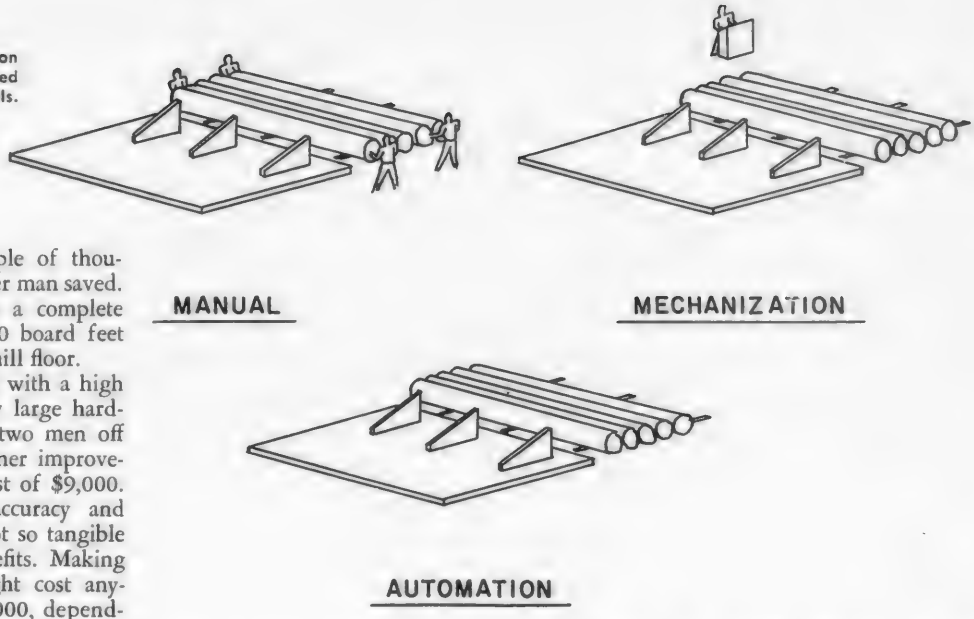
Gains Outweigh Automation Costs

Now you may be asking yourself, what does all this cost? Can I afford to automate? The question is really, can I afford not to automate? Nels Glesne, the president of Casswood Industries, a hardwood sawmill in Illinois, said at the recent FPRS meeting in Madison, "If with five thousand dollars a manager can replace a laborer he is a fool to sit around and not do something about it. If with ten thousand dollars, a worker can be replaced by a machine it is a sound investment and worth going out to borrow some working capital"[2].

If your mill has 4 men on the log deck delivering logs to the carriage and turning them, and you are spending an average of $2,500 per man on the job, or $10,000 a year, can you compete with a mill spending zero dollars a year in an automated mill for the same jobs to be done? Several years ago, our modernization took 5 men out of a mill in New Mexico—which was about to close down—at a total cost of $7,000. This included a setter, dogger and three men on the deck. The cost would be more now, what with inflation and higher prices, but it would

[2] Glesne, Nels. 1959. Small mill lumber handling. Forest Prod. J. IX(7):9-A.

Fig. 3.—Manpower comparison between manual, mechanized and automated sawmills.



not be more than a couple of thousand dollars at the most per man saved. Later this company built a complete new mill that cuts 50,000 board feet a day with 6 men on the mill floor.

A midwestern company with a high production that saws very large hardwood logs recently took two men off the carriage and made other improvements in the mill at a cost of $9,000. The increased sawing accuracy and other factors that were not so tangible added up to sizable benefits. Making a carriage automatic might cost anywhere from $2000 to $5000, depending on the carriage and what it needs, Putting air-operated dogs on a carriage can cost as little as $1600. Converting a two-saw handwheel edger to pre-set push-buttom control runs about $750. A good sawyer-controlled log turner for small logs runs $250,000. Mills that converted feel that the labor-saving devices paid for themselves, and very quickly!

[2] Glesne, Nels. 1959. Small mill lumber handling. Forest Prod. J. IX (7):9-A.

Automation Benefits Are Just Beginning

Automation developments are very advanced, and yet we are just beginning to reap the full benefits of all the wonderful technical advances for sawmills. The things described in this article are practical and are working in sawmills all over the country, some of them nearby. Other mill operators are benefiting from automation. You can too. Keep your eyes open and your mind open to the new developments, and you too will find automation the key to profitable sawmilling.

CUSHIONING FOR PACKAGING:

Engineering Wood Cellulose[1]

C. E. Swanson and A. J. Withoff
Wood Conversion Co.,
Cloquet, Minnesota

Cellulose fiber cushioning combines new physical properties for cushioning and a new engineered concept of product use that means profit for the packaging engineer.

Cellulose fibers are chemically clean materials that are manufactured from wood pulp and reassembled into a fibrous mat or blanket that will display a certain amount of resiliency and cushioning. These properties depend upon the method of manufacture. Cellulose fiber cushioning manufactured by a variety of companies in a variety of forms is in everyday life, actually from the cradle to the grave. Among other things, these products cushion our mattresses, our furniture, our automobile; they absorb our sounds, insulate us, protect our food, and filter the air we breathe, even cushion the slippers and shoes we walk in. In most of these applications, cellulose products are used because of their padding and cushioning ability. Out of all these uses the one to be

The Authors: C. E. Swanson holds a BS degree in wood technology from the University of Minnesota. He is an Assistant Manager, Industrial Technical Sales Service.

A. J. Withoff, also an Assistant Manager, Industrial Technical Sales Service, has graduated from several industrial packaging courses.

[1] Presented at Session XIII, Packaging, FPRS 13th National Meeting, June 28–July 3, 1959. San Francisco.

discussed briefly is the packaging application, and the cushioning and use attributes that make cellulose fiber products particularly appropriate for it.

Today's manufacturing and economic atmospheres pose two different problems to today's packaging engineers. For example, items that are being packaged are becoming extremely complex and delicate, as well as expensive—worth more than their weight in gold, according to President Eisenhower—and the labor necessary to wrap and cushion them, as well as handle the products that will do these jobs, is extremely expensive. Cellulose fiber manufacturers have involved themselves in considerable research to aid the packaging engineer in solving these problems—to provide adequate cushioning for a variety of fragile items and to provide a cushioning material that has the properties of being low in cost and efficient to use. What they have done is really what is new in the packaging industry today.

Physical Properties

Packaging engineers generally agree that there are six basic packaging principles: 1) flotation, 2) pressure point, 3) surface protection, 4) absorbent, 5) moisture resistant, and 6) thermal insulation. Any single package will utilize one or more of these principles, and to say that one product family will meet all of them is quite a statement, but cellulose fiber cushioning does. The names of these principles are quite descriptive in themselves, for flotation is the floating of an item on the cushioning for protection—the item will be completing surrounded by cushioning of the proper thickness and density.

Pressure-point padding means just that—the cushioning of projections or bearing areas to protect the item from shocks it may receive, damage from the outside container, or even to prevent damage to the outside container from the item itself.

Surface protection involves the use of a cushioning to preserve a polished, painted, or finished surface from marring that could occur during transit. Absorbent packaging is that in which the cushioning will absorb the entire liquid contents of a packaged item should it break or furnish liquid to a packaged item, such as a flower or plant. Cellulose fiber felt is manufactured to absorb more than 16 times its own weight of liquid. Moisture-resistant packaging is used to protect the item from too much moisture, and in this case cellulose fiber felt again can be manufactured to absorb less than three times its own weight of liquid.

Lastly, thermal insulation is for the protection of serums, pharmaceuticals, blood, resins, candy, and many other items that must be transported in a cool or cold condition. Cellulose fiber felt is available with k factors as low as 0.23.

The principle of flotation is probably the most important single principle because it involves the most critical and most difficult to measure physical property of a cushioning product, its ability to cushion and protect items of various fragilities.

The first prerequisite necessary for choosing a specific cushioning product from the host of those available involves a determination of shock-absorbing properties. This is done through an analysis of the static stress-strain curves of the various products. In use, the engineer determines the amount of energy that is absorbed by a cushion at a certain stress. Then the ratio of the stress to the energy absorbed will result in the cushion factor of the particular product and will, in fact, indicate the efficiency of that material.

Because of the variety of package conditions such as bearing areas, weights, fragilities, dropping heights and others, it is possible that the packaging engineer will be faced with packaging conditions that require an infinite number of static stress-strain relationships[2]. In other words, cushinoing requirements are so varied that they require an extremely wide variation of products to meet them most adequately. To aid the packaging engineer, therefore, the cushioning manufacturer is prompted to design the most versatile varieties of a single product that he can.

One of the first cellulose fiber cushioning materials used was creped cellulose wadding. This product could be manufactured only to a single density, and presented a static stress-strain curve comparable to that shown in Fig. 2. One product with a single stress-strain relationship is not enough to meet all the packaging requirements that an engineer is faced with. Therefore, after examining other products with their own stress-strain relationships, the engineer found he could choose from a host of products that display curves such as those shown in Fig. 3. These curves include such

[2] Investigation of packaging materials is rapidly becoming a science, what with new methods of measurement such as dynamic testing and theories being developed to describe more accurately the cushioning properties that a product has. For technical literature that is available concerning all phases of packaging obtain the publication titled "Packaging Research; An Inventory" written by S. A. Larsen and published in 1959 as Research Study No. 37 by the American Management Association, 1515 Broadway, New York 36, N. Y.

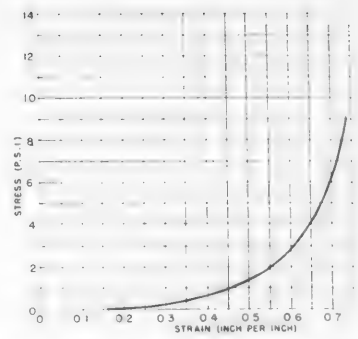


Fig. 2.—Static stress-strain curve for creped cellulose wadding.

products as rubberized curled hair, glass fibers, reclaimed sponge rubber, and others. Note that rubberized hair, which is available in a series of densities, offers an individual static stress-strain curve for each density. Other products too could be shown that would expand the total area covered by these curves, but for this discussion they would only add confusion.

With the one curve shown in Fig. 2 as a start, cellulose fiber felt research to meet a need has developed the family of stress-strain curves shown in Fig. 4. Manufacturers of creped wadding have changed the dimensions of the crepe used an included dimpling or embossing, which has changed the static stress-strain curves somewhat, but a more spectacular development is shown by what has happened to the versatility of cellulose fiber felt products. By way of a definition, a creped cellulose wadding product is composed of several plys of creped tissue, while cellulose fiber felt is a homogeneous product. For a number of years, four densities (1½, 2, 3, and 4 pounds per cubic foot) of cellulose fiber felt products have been available, and each product displays its own static stress-strain curve (see solid-line curves in Fig. 4). Now a new family of cellulose fiber felt is available, and its curves are shown as dotted lines in Fig. 4. This new product, while composed of the same ingredients as the standard felts and manufactured to an approximate 1½ pcf density, has a noticeably softer stress-strain curve. This is the result of new techniques in cellulose fiber and product manufacture. The point is that, with the need for versatile products, the cellulose fiber manufacturers have employed research to develop products with stress-strain characteristics over an extremely wide range.

Cellulose fiber cushioning will not answer every cushioning requirement, but through technical development, ingenuity, and chemical and mechanical modification of fibers and fibrous products, cellulose cushioning materials

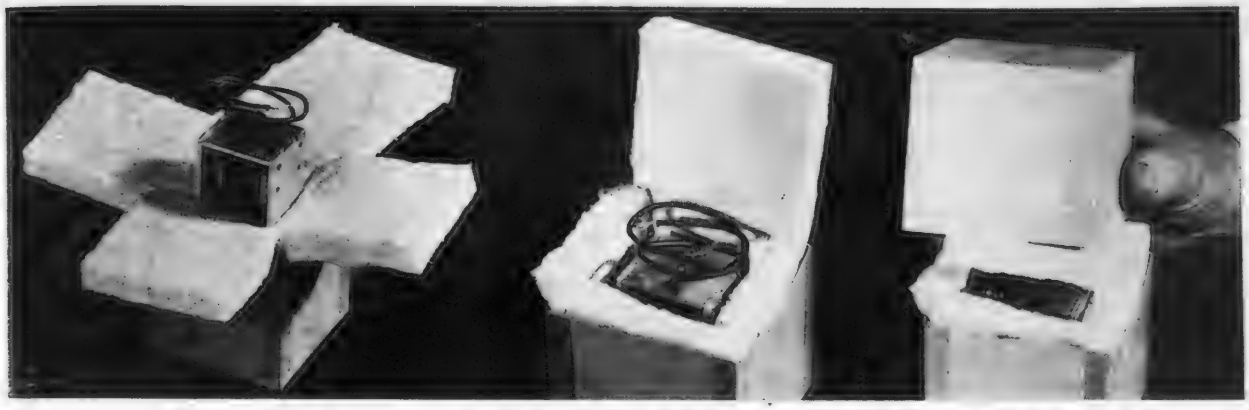


Fig. 1.—One of the most successful pre-cut shapes in use is a cellulose fiber pad cut in the shape of a cross.

have been developed that will go a long way toward satisfactorily cushioning a host of items. It must be emphasized that this range of static stress-strain data for only one group of cellulose fiber felt products produced by only one manufacturer is truly notable and important to the cushioning industry.

Many other physical properties are recorded that are pertinent to the use of cellulose cushioning as packaging material, but they are not necessary for this specific discussion. Such data for specific products are available on request from the manufacturers.

Manufacturing Advantages

The manufacturing advantages of cellulose fiber felt are important, too. Cellulose fiber felt is manufactured by a very large industry. It is mass-produced, and its cost is low in comparison to other cushioning products. The manufacturing equipment used is versatile and produces a homogeneous product in thickness of from about 1/8 inch up to 3 inches and in widths up to 10 feet. The industry is established with many years of experience and services a great number of diverse industries, and therefore has distribution facilities throughout North America. But best of all, it is a mechanized industry with machines that will cut products to shape very rapidly—at the rate of up to 30,000 pieces per hour —and that means low unit cost.

The last advantage—that it is a mechanized industry—is probably one of the most important, and sets the stage for the major contribution that cellulose fiber felt is making to today's packaging industry. So far it has been pointed out that cellulose fiber felt is being manufactured in quantity, it is used in various industries including packaging, it has the properties necessary for a package cushiniong application, and it is available throughout North America. Other products can tell almost the same story, but here is how modern mechanization fits into product use.

Packaging Application

In the old days, it was enough to wrap a product in a cushioning material, ship it, and observe the results. If the item was not damaged the cushioning was deemed acceptable, and only the most advanced companies would experiment further by limiting the amount of cushioning to conserve on cost. After all, the cellulose fiber felt that was used in volume was very inexpensive, as was the labor used, and over-all economy was not too drastically affected by reducing the padding cost.

Today's economy and method of doing business have set up criteria of speed and efficiency that must be met. For example, many military installations, department stores, manufacturing plants, and storage facilities are set up to store or manufacture goods at fantastic rates. Some of these establishments ship 10,000 to 20,000 items each and every day, and the mechanical conveyance systems and programming are the utmost that methods engineers can devise. Many times, however, these systems are bottlenecked or corrupted because no one has taken the time to appreciate cushioning materials and their use as real variables of production subject to true standardization of use.

This is important—consider these thoughts. In the first place, at a large manufacturing plant speed is a foregone conclusion, for if a factory is turning out 10,000 items every day on contract or orders, 10,000 items must be packaged and shipped that day. Secondly, labor costs today are higher than they have ever been before. Thirdly, overhead or burden that is usually assigned to direct labor and, therefore, chargeable or costed against a particular factory operation, is also higher than it has ever been before.

To see what this means, consider a hypothetical case. Suppose that a packaging person being paid $2 per hour requires three minutes to wrap one square foot of cushioning around an item being packaged. To account for overhead or burden in the modern manufacturing plant, the common accounting practice is to add that burden to the labor charge. According to the Department of Commerce, an average burden being used in the United States today is about 230 percent of the labor cost; therefore, although the worker is paid $2 per hour, it actually costs the manufacturer $2 plus 2.3 times $2, or $6.60 per hour to have that man on the job. This is 11¢ per minute, so if it requires three minutes for the man to do the job it has cost 33¢. Next, realistically assume that the cushioning material costs 5¢ per square foot. It thus will have cost 38¢ for labor and materials to put a simple wrap of one square foot of cushioning material around the item.

The most expensive part of this operation is the labor, which is valued at six times the cost of the cushioning. It does not require much imagination to determine which cost—labor or material—should be examined for possible cost reductions. As an example of what can be done, suppose that at a cost of 2¢ per square foot the cushioning could be modified to make it more readily usable. This would give a total cost of 7¢ per square foot for the cushioning. This modification allows the packaging person to wrap the item in one minute instead of three. The sum of the costs would be 7¢ for materials and 11¢ for labor, or total of 18¢, just about one-half of the previous example, even though the cushioning price was increased. This represents a definite savings in dollars to the packaging man, but more than that a saving of manpower, for either fewer men could do the same job or the same number of men could handle

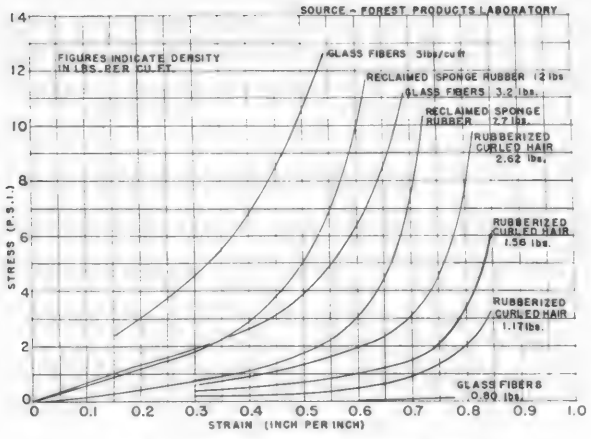

SOURCE - FOREST PRODUCTS LABORATORY
FIGURES INDICATE DENSITY IN LBS. PER CU. FT.
GLASS FIBERS 5lbs/cu ft
RECLAIMED SPONGE RUBBER 12 lbs
GLASS FIBERS 3.2 lbs.
RECLAIMED SPONGE RUBBER 7.7 lbs.
RUBBERIZED CURLED HAIR 2.62 lbs.
RUBBERIZED CURLED HAIR 1.56 lbs.
RUBBERIZED CURLED HAIR 1.17 lbs.
GLASS FIBERS 0.90 lbs.
STRESS (P.S.I.)
STRAIN (INCH PER INCH)

Fig. 3.—Several static stress-strain curves.

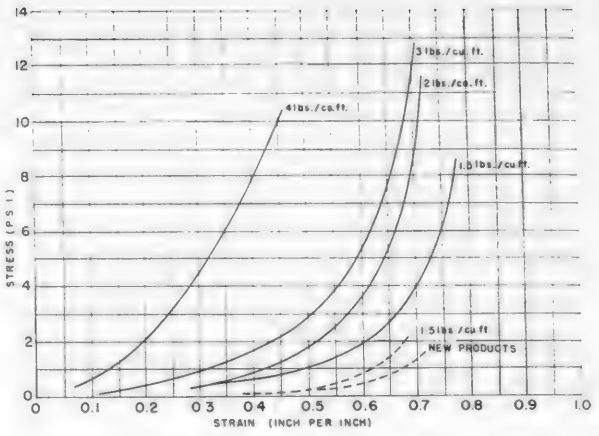


Fig. 4.—Static stress-strain curve for cellulose fiber felt.

substantially more packages per interval of time.

The above is not truly a hypothetical case; it is actually true and can be pointed out in many instances today. The actual case is that in the first example the packaging line is utilizing roll goods or slab-stock packaging material, and the worker tears or cuts what he considers an adequate amount —approximately one square foot— from the roll, wraps it around the item, and forces the total into a container. An operation such as this can take three minutes or even more, depending upon how the man feels. In the second case, instead of using roll or slab packaging goods, the worker has used a pre-planned cushion, which is actually the same roll goods that has been modified by cutting into shapes that are ideal for the items he is packaging. One of the most successful shapes in use is a pad cut in the shape of a cross, as shown in Fig. 1. When such a pad is used to package a capacitator, for example, the pad is first positioned on top of the outside carton. Next, with one hand the worker places the capacitator on top of the pad and pushes it, pad and all, into the carton. Then the ends of the cross are folded down over the capacitator and the top of the container is placed in position. Contrast this with the operations that would be required to do the same thing, but with material torn from a roll. This is modern cushioning for the modern packaging eingineer because it allows him to specify and control not only the packaging material, but also its use.

The cross is only one example of a cut-to-shape piece of cushioning that can be designed to fit a production packaging situation. For others there are triangles and T-shaped pieces, as well as simple squares and rectangles. In all cases, the objective is to provide cushioning with the least expenditure of labor by simplifying the actual packaging operation.

Consider standardization and the advantages from pre-cut cushioning. Dollar savings are realized because there are fewer time-consuming motions required to wrap the item. Preplanned and adequate cushioning is specified and used, because the supervisor or packaging engineer determines the piece size and its application, not the packaging-line worker. Waste is reduced because each piece is exact and totally usable. Cleanliness is insured because on-the-job fabrication with resulting scraps and shreds from torn material has been eliminated. Weight, too, is controlled, and this is particularly important in any parcel post system. Actually, the use of exact shapes will eliminate cushioning weight variation. By eliminating two ounces per package in a system that mails 70,000 packages per month, 4½ tons of excess weight could be saved per month.

The important savings—dollar-wise —result directly from standardization of products, and their application and standardization is possible in the most diverse of packaging systems. A parcel post packaging system of a large military supply center (or a sizeable department store) is a good example. One such installation inventories quantities of over 600,000 different items and mails 70,000 items each month. By setting up this parcel post line, some standardization has already evolved as far as over-all size is concerned. Through experience it has been found that over 90 percent of the items shipped each month can be contained in 11 set-up and corrugated cartons that vary in dimension from a minimum 2 by 2 inches by 1 inch to a maximum 10 by 8 by 6 inches. Because of the common dimensions used in these cartons, only five pre-shaped pieces ½ inch thick and cut to the shape of a cross are necessary to handle over 90 percent of the items shipped. To obtain this standarization some items are over-packed, to be sure, but the cost of the excess cushioning used is far less precious than the savings achieved.

It must be pointed out that this example of a parcel post packaging line was chosen because it appropriately shows what can happen when a large-volume, very diverse system is encountered. Other packaging lines, such as specification packaging systems for small parts, production lines at manufacturing companies that specialize in one type of item, and others that are already standardized somewhat are even more appropriate for the use of packaging materials that will reduce packaging labor costs.

Conclusions

Prefabrication is proven and accepted as a proper labor-saving and necessary step in today's labor-conscious industry. Cellulose fiber felt cushioning offers those same advantages.

In summation, the use of cellulose fiber felt cushioning is the "what's new" in the packaging industry today. Through research and manufacture, cellulose fiber felt is a more versatile product from the standpoint of cushioning properties than it has ever been before, and it is suitable for use with products with extremely varied fragilities. Through research in use, the cellulose fiber felt industry has developed engineered methods of product use that are newly applied to the packaging industry. The profits from this research are enjoyed, of course, by the cellulose fiber manufacturers, but, more important, they are to be enjoyed by packaging engineers and the companies they represent because cellulose fiber felt has been engineered to meet their high-speed, high-cost packaging needs

Fig. 1.—The first multiple-head, wide-belt sander that affords the user a complete sequence of grits.

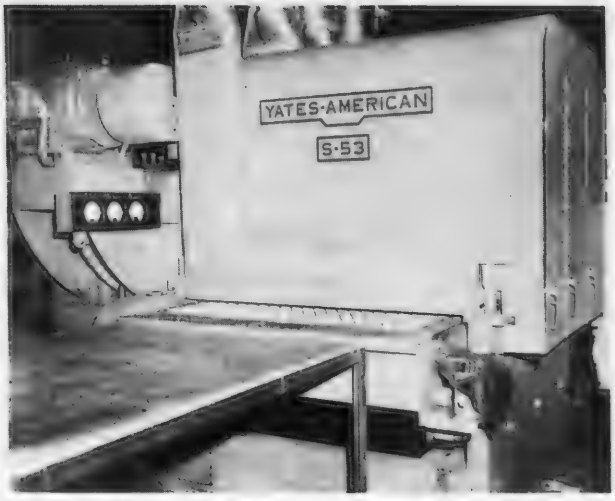


Fig. 2.—The Yates–American S-53 Combination Drum and Belt Sander.

TREND IN WOOD SANDING: Wide Belts[1]

H. L. Bennett
Behr–Manning Co., Troy, N. Y.

Heavier sanding machines that operate with less expensive cloth-backed abrasive belts will benefit the woodworking industry through improved finish, increased production, and lower costs.

To offset higher manufacturing costs and to meet more exacting requirements by the customer, the woodworking industry has found itself compelled to improve finishes and increase output—per man and per dollar of plant capital invested. Such demands call for better wood-sanding methods. Accordingly, the industry has called on manufacturers of woodworking machinery and coated abrasives to design and build products that will meet these demands.

The basic problem was to develop equipment that could be operated simply, would assure uniformly good finish, and speed up production enough to justify the added investment. Sound logic pointed to the development of wide-belt machines capable of sanding a complete surface with a single pass.

For several years, leading machinery builders have been hard at work designing prototype units, making field tests, and modifying their designs to include the improvements suggested by the testing. Today, many such new machines are producing successfully in actual plant use.

New Belts Needed for Top Machine Performance

Moreover, the woodworking manufacturer is now offered a wide choice of equipment as he seeks the unit best adapted to his particular operation. Today there are no fewer than eight manufacturers who have developed wide-belt equipment—Mattison Machine Works, J. M. Nash Co., The Oakley Co., Sherill Machine Co., Smithway Machine Co., Timesavers Inc., Union Tool Corp., and Yates–American Machine Co. Others are expected to follow.

While this evolution in machinery was taking place, it became evident that manufacturers of coated abrasives had to keep step—to develop belts that would permit these improved machines to perform their best.

Fortunately, the coated abrasives industry could call on a large fund of experience gained through supplying such belts to the metalworking industries. For wood, however, special joints had to be developed, because joints any thicker than the belt itself would produce unacceptable markings on fine finishes. Also, resin-bonded products became necessary in order to extend belt life. Improved coating techniques and proper flexing became compulsory. Fortunately, the great majority of plants are able to keep costs in line by using paper-backed belts on the new equipment, rather than the more costly cloth belts.

Today, wide belts of coated abrasive are showing improving performance in production while still meeting the stiffer requirements as to finish. Popular grits range from 60–E (½) through 400–E (10/0). The site depends on the condition of the stock and the degree of finish required.

In the West Coast plywood industry, such wide-belt machines are already stepping up production rates and delivering improved finish—two advances that are making it possible for the industry to compete with imported plywood.

The Author: Harvey Bennett holds a BS from Canisius College, Buffalo, New York. He is National Products Engineer Behr-Manning.

[1] Presented at Session XI, Wood Finishing, FPRS 13th National Meeting, June 28–July 3, 1959, San Francisco.

Fig. 3.—The Roll Feed Sander manufactured by the Smithway Machine Co.

Fig. 5.—The 50-inch 58 Flatbed Sander manufactured by J. M. Nash Co.

Behr–Manning has surveyed mill owners and superintendents in recent weeks, and has encountered such statements as "We couldn't operate at our present production rates without the wide belts." "They have made it possible for us to run profitably". "With drum sanders we can't sand or polish ¾-inch items, which are what we want to produce". "The wide belt can handle the warped or undulated panel without cutting completely through the 1/28-inch face stock."

An official of the Plywood Research Foundation said that his industry is seeking not only manufacturing economies, but improved quality as well. In his opinion, the wide-belt sander is destined to revolutionize plywood sanding within the next few years. He quoted production figures at one mill that is polishing 2500 to 2700 panels per shift, and getting a belt life of 40 hours.

In one mill, the owner stated, "The 50-inch sander put us in the hardwoods business. When our new machine is in full operation, we expect at least 2000 panels per day every day. We're planning to feed the work at 75 feet per minute."

This same owner described with obvious pride an unsolicited letter from a customer thanking him for the "beautiful" finish he was delivering since his wide-belt machine went into operation. Another letter said, "Henceforth we are getting 100 percent of our requirements from you."

The Machines and the Products They Handle

Throughout the industry, it is apparent that the lighter machine of yesterday, even when modified, lacks the "beef" required to maintain consistent production at such high rates when used to cut down patches of .030 inch or more in thickness and, at the same time, must conform to slight irregularities in surface flatness. It is significant that two of the newer wide-belt machines weigh 12 tons each, and apply 50 horsepower to each abrasive belt.

The various machines and the kind of product the equipment is designed to handle will be described briefly.

The S–53 Combination Drum and Belt Sander, manufactured by Yates–American Machine Co. of Beloit, Wis. This is the first multiple-head belt sander that affords the user a complete sequence of grits. Thus it can size, cut down, and polish in a single operation. To meet a variety of applications, the unit is designed to use a spirally wound drum, a serrated rubber contact roll and abrasive belt, and a flexible platen assembly with belt—or any combination of these.

For example, the machine can be furnished with three belts that run over two contact rolls and a platen, or with a combination of one contact roll and either two or three platens. Belt tracking is controlled automatically by air to assure proper tension and oscillation.

The endless-bed feed has been engineered to provide feed rates of 30 to 90 fpm. Properly designed pressure platens prevent dubbing of stock. The 103-inch belt is ordered in 50- or 55-inch widths, depending on the job. This equipment is designed to process hardwood, fir plywood, and furniture dimension stock.

The first West Coast installation has been made at Klamath Hardwood Company, Klamath Falls, Ore. It is a three-platen machine.

Roll Feed Sander manufactured by Smithway Machine Co. of Seattle, Wash. This machine is the first over-and-under wide-belt sander, a design that makes it possible to sand both the top and bottom of the stock in a single operation.

It is equipped with two rubber contact rolls, one each for the top and bottom belts. Each contact roll is opposed by a billy or pressure roll. Four sets of powered pinch rolls feed stock at rates that can be varied from 30 to 100 fpm.

Automatic belt tracking and air tensioning assure good control of the abrasive belt, which is 50 by 145 inches in size. Although the unit is designed principally for sanding repatch fir plywood panels, it is expected to show good results on hardwood panels as well. The first installation has been made at a large California mill.

50-inch 58 Flatbed Sander manufactured by J. M. Nash Co. of Milwaukee, Wis. This machine is a single-belt, bottom-side sander designed for cutting down and polishing furniture dimension and plywood stock. It is available with a serrated rubber contact roll or a platen assembly. Automatic belt tension and tracking control combine to provide uniform oscillation. The flat bed and the method of feed

Fig. 4.—This Roll Feed machine is the first over-and-under wide-belt sander.

Fig. 6.—The 58 Flatbed is a single-belt, bottom-side sander designed for cutting down and polishing.

Fig. 7.—No. 456 Grinding Machine, a single overhead-belt machine built for heavy sizing operations by Mattison Machine Works.

by an overhead rubber belt backed up by a metal platen make possible a range of feed rates from 30 to 70 fpm. In addition, this combination straightens the stock to prevent dubbing. The abrasive belt size is 50 by 162 inches.

The latest installation of this machine was made at the International Paper Co. plant in Longview, Wash. The 38-inch, 58 model, which uses a belt 38 by 162 inches, is currently in wide use in the furniture industry for processing dimension stock, both solid and veneer.

No. 456 Grinding Machine manufactured by Mattison Machine Works, Rockford, Ill. This is a single overhead-belt machine built for heavy sizing operations. The unit is equipped with a serrated rubber contact roll opposed by a billy roll and two sets of pinch rolls to supply feed speeds up to 150 fpm. It uses a 54- by 243-inch abrasive belt, which is tensioned, tracked and oscillated automatically.

The most recent installation was made at Algoma Plywood Corp., Algoma, Wis.,, for sizing fireproof doors.

B–52A Speed Feed Sander manufactured by Sherrill Machine Co. of Troutman, N. C. This, the original wide-belt machine, is a bottom-side sander that has a serrated rubber contact roll opposed by twin feed rolls to provide continuous flow of stock through the unit. Stock is supported by an adjustable infeed table and outfeed rolls. Special self-aligning pulleys control belt tracking. Feed speeds range from 30 to 100 fpm, and the belt is 50 by 93 inches. This machine is designed for sanding hardwood plywood panels and flush panel doors.

Model B–38A Belt Sander (for 38- by 93-inch belt) is designed for processing sub-assembly stock for furniture. The Model B–24A Belt Sander (24- by 93-inch belt) is also available for small stock. Sherrill equipment is the lowest-priced wide-belt equipment on the market. Numerous machines of these types are operating successfully in production.

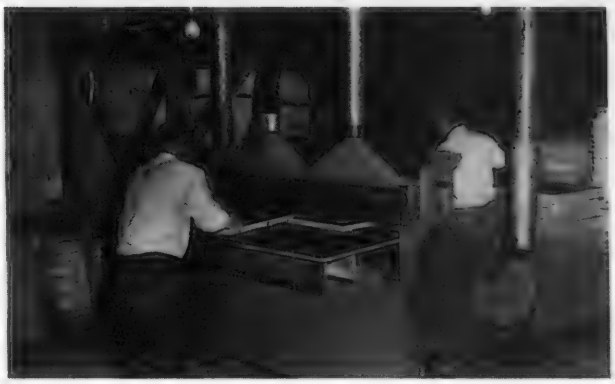


Fig. 8.—The original wide-belt sander, the bottom-side B-52A Speed Feed Sander produced by Sherrill Machine Co.

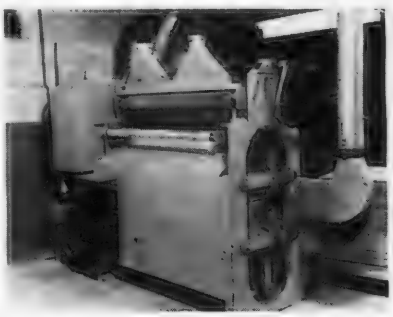


Fig. 9.—The Model B-38A Belt Sander (Sherrill) is designed for processing sub-assembly stock for furniture.

Fig. 10.—An overhead-platen sander, the Indiana Sander, manufactured by the Union Tool Corp.

Indiana Sander manufactured by Union Tool Corp. of Warsaw, Ind. This is an overhead platen sander designed with hold-down rolls and a rubber conveyor belt supported by a flat bed. The unit is equipped with automatic control of belt tension and tracking. Feed speeds range upward to 100 fpm; belt size is 43 by 111 inches. The Indiana machine is designed to process furniture dimension stock.

Oakley Sander manufactured by the Oakley Co. of Bristol, Tenn. A pinch-roll feed machine for processing furniture dimension stock, it employes an overhead belt unit with a rubber contact roll and special manual control of belt tracking. Feed speeds range from 30 to 90 fpm. Belt size is 24 by 144 inches.

These machines will unquestionably produce substantial benefits for the woodworking industry—in improved finish, increased production, and lower costs. In any language, these advantages spell profits.

A SEARCH FOR BETTER

Particle Board Adhesives[1]

J. W. Maxwell, G. Kitazawa, T. F. Duncan and J. M. Hine

The Borden Chemical Co., Bainbridge, New York

The Urea-formaldehyde resin normally used in particle board board does not resist the combination of heat and moisture. To date, the most durable particle boards have been obtained with phenolic resins.

Fig. 1.—Samples after steam phase of accelerated aging cycle.

THERE ARE MANY APPROACHES to the development of a durable particle board binder. The first would be an analysis of the causes of adhesive failure in a board. This necessitates an understanding of polymer chemistry and physics, adhesion and cohesive forces, particle geometry and size distribution, and the stresses set up between individual particles in a board with changes in moisture and temperature.

Fundamentally, two types of failure are assumed to occur in the adhesive bond between wood particles: the failure in interfacial adhesion between wood and adhesive, and failure of cohesion within the resin. There is also a third type of failure, the failure that occurs within the wood particles as dependent on geometry, method of particle preparation, and the relative strength of wood and adhesive at any particular juncture. Since we speak only of total failure, this is a simplified picture of what actually does happen, for in essence each failure area may combine all three.

Resin Coverage

It can be shown by light microscopy that resin distribution for most particle board processes is not continuous. Only in rare instances are some localized particles completely coated with excess resin which would indicate poor mixing conditions. It can also be shown that the total surface area available for gluing is large and varies considerably with particle geometry and distribution. Glue spread is expressed in pounds per 1000 square feet of surface for lumber gluing and plywood manufacture; on the other hand, the spread for particle board is unusually low, better given in grams or a fraction of a gram per 1000 square feet of surface area depending on particle geometry and size distribution.

For some of the particle systems examined, the computed thickness for a continuous adhesive coating would be a small fraction of a micron and possibly might better be measured in Angstrom units.

There is the belief that a continuous film would be more desirable than discrete droplets.[2] As the adhesive distribution will be discontinuous for all dry-process boards, the particles are bonded by numerous minute "spot-welds". At the ordinary binder percentages, therefore, the resin itself affords no barrier to moisture entry and transfer. Thus, the spatial arrangement of the adhesive might be considered as a three-dimensional lattice of glue points in space rather than a foamed resin system in which each bubble would represent the film surrounding a wood particle. Moisture has, therefore, free access to all particles in a board. Additives and particle coatings may reduce the rate of moisture movement, but the fact remains that the "spot-welds" are exposed to attack. The effect of moisture and temperature on the "spot-welds" is determined in part by the chemical and physical nature of the adhesive. Changes in moisture content of the wood particles will further create a stress pattern on the resin.

The Authors: J. W. Maxwell, Technical Service Manager, holds BS and MS degrees from the New York State College of Forestry. He was formerly associated with American Cyanamid and Masonite.

George Kitazawa received his BS from the U. of California, and MS and PhD from the New York State College of Forestry. He is now Assistant Head of the Central Research Lab at Phildelphia.

T. F. Duncan holds BS and MS degrees from the New York State College of Forestry. He is presently a wood technologist at the Sales Development Lab., Bainbridge.

J. M. Hine holds a BS in chemistry from the College of Puget Sound, Tacoma, Wash., and did graduate work at the U. of Oregon. He is now Development Manager, Western Operations.

[1] Presented at Session XIX, Wood Composition Board, FPRS 13th National Meeting, June 28–July 3, 1959, San Francisco.

[2] Marian, J. E. 1958. Adhesive and adhesion problems in particle board production. Forest Prod. J. VIII (6): 172.

Some Factors Involved in Durability

Adhesive and Cohesive Strengths: As noted, "adhesion" as used in this paper refers to the forces that exist between the surface of the resin mass and the wood substrate, whether obtained specifically or mechanically. "Cohesion" refers to the internal strength of the resin binder subjected not only to tensile but also shear and torsion forces, the latter two being important because of the random orientation of the grain direction of the particles.

An adequate binder from the adhesive manufacturers' viewpoint is one in which the adhesive and cohesive forces are sufficiently high to result in wood failure. An ideal binder would be one in which further contributions would be made in ultimate wood strength in addition to the required levels of adhesion and cohesion.

Since the great majority of particle board manufacturers presently use urea-formaldehyde, it is of interest to know why these particular binders have inadequate durability. It is well known that chemical deterioration with time is the prime reason for inadequate durability in urea-formaldehyde resins. This deterioration can take place at various points in the resin structure, primarily at the methylene bridges, under high humidity and temperature conditions. Therefore, low cohesive forces are believed to be responsibile for eventual failure.

The objective of adhesive research in this field is to develop systems with cohesive forces that remain high in the presence of moisture under high temperature and at the same time retain the original level of dry state adhesion. These forces are created in the laboratory when a sample of particle board is subjected to the ASTM Accelerated Aging Test.[3]

Stresses at the "Spot-Welds": Although in the case of urea-formaldehyde, chemical deterioration is a factor in durability, the failure of boards is actually accelerated by changes in moisture and temperature. Wood particles swell and shrink under moisture absorption and drying. If two particles are held together so that their grain directions parallel each other, the stress differences under moisture changes between the two particles result from the tangential and radial differences of the kinds of wood involved, the density, and the extent of the wood backing the contact area. On the other hand, if the two particles are at right angles, longitudinal properties come into effect and produce an entirely different stress pattern in which shear stresses will predominate. This stress pattern is in part a function of the angle of the grain directions of the facing particles. With the insertion of a discontinuous glue line of minute adhesive droplets, the shear stress will increase with increasing angle, and reach a maximum at 90°. It is believed that these shear stresses accelerate the failures within the board. Thus, each particle-to-particle cotact represents a unique juncture with its particular stress pattern.

Although the conventional urea-formaldehyde resin may be adequately durable for certain flat stock gluing, the use of such binders becomes questionable for particle boards where the shear stresses are appreciable for the small adhesive contact areas. It is interesting to note that this random grain orientation makes for a more dimensionally stable board, and one that must rely on a small amount of ahesive for this stability.

Screening Test for Evaluating Durability

In the evaluation of experimental binders, it is often necessary to set up initial screening tests to determine the more promising binders developed by the polymer or resin chemists. This initial screening is desirable to cover a certain phase of the adhesive development project more effectively before any elaborate large-scale program of standard accelerated aging tests is undertaken. Several screening tests were devised so that the chemical work could proceed smoothly.

A cross-lap specimen was chosen for the initial screening. A radical departure from the usual particle board preparation was the specification for a ¼-inch-thick board. Small test specimens followed ASTM plastic testing specifications. Further, 6 by 6 by ¼ inch particle board squares were exposed for thickness expansion and surface variation studies. It should be noted that the ¼ inch thickness is more prone to variations, since in certain particle systems, single particles can traverse the thickness; however, in screening tests, this was not serious.

Cross-Lap Durability: Cross-lap specimens were thought to give the maximum shearing force on the glue line when exposed to high humidity and temperature. Although it might be desirable to design a specific cross-lap specimen to simulate the worst condition for a adhseive-wood juncture, it was decided to use the cross-lap specimen designed by Marra[4] for the tensile strength evaluation of the dry strength of various adhesives.

The glued cross-laps were subjected to boiling water and oven-drying, one cycle consisting of 15 minutes of boiling and 40 minutes of oven-drying at 105° C. For certain resins, the boiling treatment probably caused the further cure of the resin and therefore was not a realistic measure of durability as would be obtained in field tests. Nevertheless, it was possible within a day to determine the relative durability of the binders. Unfortified animal glue and polyvinyl acetate would invariably fail within the first cycle of test. Properly glued resorcinol-formaldehyde and phenol-formaldehyde cross-laps could be expected to exceed 10 cycles of such treatment. In the case of resins for particle board application, the hot-pressing was carried out on ⅛-inch hard maple laps to which thicker backing blocks were glued with resorcinol-formaldehyde after pressing to give t herequired specimen size. Urea-formaldehyde binders ranged between the two extremes of the non-durable and durable adhesives.

Particle Board Testing: Modulus of rupture tests were conducted on the small particle board strips. Aedquate screening could be obtained even with samples whose cross-sectional dimensions were only ¾ by ¼ inch. These data were then related to the results of the exposure of 6 by 6 by ¼ inch particle board squares to 100 percent humidity at 180°F. The expansion percentages and the surface characteristics as to roughness and individual particle adhesion were compared to boards containing phenolic binder as a reference standard. These tests as described were useful in identifying the more promising binders. Emphasis was then placed on these in the further chemical synthesis, planning, and physical testing program.

New Durable Binders for Particle Boards

The area of new, durable particle board adhesives is one in which economics is a prime factor. The binder cost must be such that board manufacturers would find it acceptable. The limits are dictated by the economics of board production and market value of the end product. The researcher in durable adhesives for particle board cannot consider cost as the first objective, but must seek out the fundamental principles that make for a more durable adhesive. Once this information is gained, the next objective is whether the necessary requirements for durability can be brought into the realm of present-day practice and costs.

Adhesive manufacture is a highly competitive business, and information on new developments is closely guarded. Therefore, the following represents general areas for research and development.

[3] American Society for Testing Materials. "1952 Book of ASTM Standards", p. 845.

[4] Marra, A. A. 1955. A new method for testing wood adhesives. Forest Frod. J. V (5): 301.

Up-grading Urea-formaldehyde Resin: The adhesive qualities of urea-formaldehyde have long been recognized. Until durability became a necessary requirement, this adhesive was considered satisfactory. The deterioration of unfortified urea-formaldehyde under heat and humidity with subsequent loss in cohesive strength practically eliminates this adhesive for durable particle boards. Yet, it appears that urea-formaldehyde can be upgraded without present means of fortification. Tests have shown that highly durable urea-formaldehyde adhesives can be prepared. Unfortunately, the working properties are such at present to be unapplicable to particle board manufacture. Much work remains to be done in this area.

Vinyl Adhesives: Studies in vinyl adhesives have shown that durability can be developed, but these binders lack the high "grab" of the urea-formaldehyde adhesives. The problem, therefore, is not one of cohesion but one of raising the interfacial adhesion values to gain the equilavent characteristics of the urea-formaldehyde. To date some of these experimental resins have given the lowest initial expansion percentages for the 6 by 6 inch particle board squares.

A number of other experimental binders have been prepared in the laboratory; they meeet most of the requirements except cost. These adhesives will eventually come into use when the costs of other competitive materials exceed present cost figures for particle board production.

Standards for Particle Board

In considering particle board for building construction, certain shortcomings of the board industry in general are apparent. The lack of standards and specifications are probably the greatest of its faults. Because of this, it is necessary for these boards to conform with tests and specifications currently used for other wood-based sheet materials. Probably the most stringent requirement to which building boards must conform is that of durability as determined by an Accelerated Aging Test as prescribed by the ASTM. Essentially this consists of 6 cycles of alternate soaking, steaming, freezing and baking[3].

Since this is the most severe test used for these types of products, it is the one that is used for determining the suitability of an adhesive for making a durable, medium-density particle board. Standards for the Accelerated Aging test lack detail as to method used for analyzing test results; therefore, the presentation is patterned after that used with insulated sheathing boards, that is, the use of breaking load for computing strength retention[5]. A 50 percent strength retention is necessary to be considered suitable for use in making a durable board. Fig. 1 shows board samples after the steam phase of an Accelerated Aging cycle.

[5] Office of Housing Expeditor, Housing and Home Finance Agency. 1947. Manual on Wood Construction for Prefabricated Houses. p. 85.

Test Procedures

Strength in flexure is the board property of primary concern in determining the acceptability of a durable adhesive. Laboratory equipment usually limits the dimensions of the board that can be made. To establish more fully the merit of a smaller flexure specimen, the first experiment described under this group was conducted.

Another property of importance for determining the value of a resin as a particle board binder is that of internal bond strength. This is indicative of resin strength, degree of cure, or both. To refine the technique for determining this board property, the second study reported under this heading was conducted.

Experiment 1: Effect of machine head speed and span length on flexure values of ¾-inch particle board. Six commercial boards representing three types of particle board (2 flake, 2 splinter, and 2 extruded boards) were used to determine the effect of span length and machine head speed in flexure values. Ten replica samples for 3 spans (6, 12, 18 inches) and 5 machine speeds (0.5, 0.05, 1.0, 2.0 and 4.0 inch per min.) were used for the 2 flake and 1 splinter type boards. Five replica samples for each of 2 machine directions (parallel and perpendicular to machine direction), 3 span lengths, and 5 machine speeds were used for the other splinter and 2 extruded boards. A typical test specimen is shown in Fig. 2.

After the individual breaking loads were converted to modulus of rupture values, the data were analyzed by the analysis of variance technique. Coefficients of variation were determined to find the most suitable combination of span and head speed with the least variation in results.

Conclusions: The MOR values of multi-platen boards (splinter and flake) were significantly affected by machine speed and span length. A fiber stress of 0.15 inch per minute, which corresponds to 1.2 inches per minute head speed on a 6-inch span, gave the least amount of variance (as determined by coefficient of variation).

Flexure properties of extruded boards are significantly affected by span and board direction due to manufacture, but not by machine speed. A 12-inch span gave the least variability in results with this type of board.

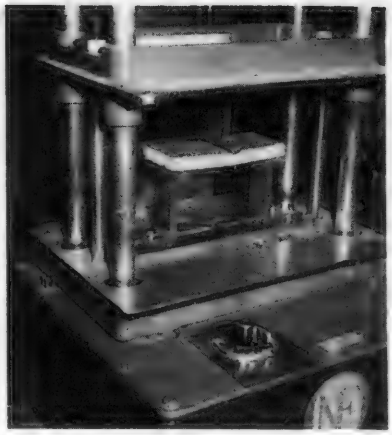


Fig. 2.—Typical test specimen for flexural values.

Experiment 2: Internal bond determination. This study was initiated to evaluate two types of test specimens for use in determining the internal bond strength of particle board. One type is a plug specimen (variation of Formica pushout test) and would be particularly well adapted for use in production where time involved in preparing standard test specimens is prohibitive. The second type is a modified tension sample based on a cross-lap (similar to Marra cross-lap specimen) arrangement of the loading blocks, and permits using the National Forge Testing Machine for more accurate testing. Force is applied by pushing the blocks apart. Fig. 3 depicts a plug test, while Fig. 4 shows a cross lap specimen.

Ten replicas were tested at 3 machine speeds for comparing the standard pull specimen with the cross-lap push sample on the Tinius Olsen Testing Machine. The same number of specimens and conditions were used to compare the push type with the plug test on the National Forge. Results were treated statistically, and the following conclusions were drawn:

1) There is no difference (1 percent level) between the push and pull specimens as tested on the Tinius Olsen Testing Machine.

2) Higher internal bond strengths (approx. 13 percent) and less variation in results were obtained with the National Forge.

3) The plug test has merit and gives results that are comparable (not significantly different at 1 percent level) with the pushout test at a machine speed of 0.05 inch per min. on the Forge machine.

Board Design

It would seem that a board should be designed for use with a durable binder to obtain optimum properties The following investigations were conducted with this thought in mind.

Fig. 3.—Plug test; a variation of the Formica pushout test.

Experiment 1: Effect of particle type, species, and resin content on durability of medium-density particle board. Boards of two densities with 7 and 10 percent solids of a phenolic (Cascophen HP–403) resin were made. Two chip types, representing 4 species, were used. Two splinter boards and one flake chip were of hardwood species, while the fourth was a softwood splinter. Each board was cut to obtain four 3 by 7 inch flexure sample; two were tested as controls while the remaining two were subjected to accelerated aging. Volumetric expansion and percent strength retention after six cycles of aging were computed for the various boards. The following conclusions are based on these test results:

1) A 50–70 percent strength retention is possible with commercially available chips with 7 percent phenol resin solids. In general, softwoods with a low specific gravity are more desirable for making a durable particle board to pass the ASTM Accelerated Aging Test.

2) Increasing the resin solids and correspondingly the pounds of resin per cubic foot of wood is more effective for reducing the volumetric expansion than for increasing strength retained.

3) A permanent volumetric expansion was noted for all boards. The greatest was noted with the hardwood species, flake chips or both. The amount of expansion increases as the density difference between the board and species used becomes greater.

Experiment 2: Effect of press temperature of durability of medium-density particle board. White pine splinter chips were used in conjunction with 8 percent solids phenol formaldehyde resin to determine the effect of press temperature on board durability. Three quarter inch boards of 2 densities were pressed at 350° and 450°F. for 12 minutes. Four 3 by 7 inch flexure samples were cut from each board; 2 were tested as controls while the remaining 2 samples were subjected to 6 cycles of accelerated aging.

Boards pressed at 450°F. retained 46 percent of their original strength as compared to 33 percent for those pressed at 350°F.

Experiment 3: Evaluation of the hardboard technique for making a durable medium-density particle board. Medium-density boards were made with aspen flakes, and an aspen-oak hardboard fiber blend and 7 percent solids of Cascophen HP–403 by the technique used in manufacturing dry-formed hardboard (spraying resin diluted to 5 percent solids and redrying fibers before board formulation). A platen temperature of 400°F. was used for a press time of 12 minutes. Four 3 by 7 inch flexure samples were cut from each board; 2 were tested as controls while the other 2 were subjected to 6 cycles of acelerated aging.

This technique did not make a board that passed the accelerated aging tests. The hardboard fibers made boards that retained the greatest percent of their original strength, but the aspen boards with a greater initial strength had double the final strength of those made with hardboard fibers.

Experiment 4: Improving chip dimensional stability and their performance in a durable particle board. Three types of stabilizing treatments were used in an effort to improve the performance of a mixed hardwood splinter chip in a durable board. Boards of two densities were made, with the amount of binder being determined by the stabilizing treatment.

Two additives, one an acrylonitrile latex and the other a coal tar emulsion, were employed at 6 percent solids after an initial 2 percent solids treatment of a liquid phenol-formaldehyde resin (46 percent).

Other chips were pre-treated with a 50 percent solids phenolic resin (compregnite) at levels of 10, 20 and 30 percent, stored for several days, and dried at 210°F. A binder level of 5 percent (46 percent solids liquid PF) was used with this treated material in board mnaufacture.

The final effort directed toward improving board performance was that of a chip formaldehyde treatment. Inhibited formaldehyde (37 percent applied at solids levels of 4 and 8 percent catalyzed with 2 percent zinc chloride in the presence of heat (180° F.) was employed. A 6 percent formaldehyde level in conjunction with 0.5 percent boron triflouride was also used. Boards were made with these chips and 8 percent solids of a phenolic resin (Cascophen HP–403—46 percent solids).

The only boards made of pre-treated chips that gave a satisfactory performance when exposed to 6 cycles of accelerated aging were those treated with the phenolic impregnant. These retained 43 to 65 percent of their original strength, but control boards made with untreated chips and a higher binder level (7 versus 5 percent) performed as well.

Resins Screened

Experiment 1: Use of phenol-modified polyvinyl acetate emulsions in durable particle board. Particle boards were made with two phenol-modified PVAc emulsions (Polyco 520 and 564) at three resin solids levels and white pine splinter chips. Data on physical properties of these two indicate that it would not be possible to make a more durable board than is obtained with a conventional UF binder. Accelerated aging studies were not made.

Experiment 2: Evaluating a melamine-urea formaldehyde and a melamine-fortified urea formaldehyde resin in manufacture of a durable particle board. Particle boards were made with a 65 percent solids liquid UF resin fortified with various levels of a melamine formaldehyde resin and a 60 per cent melamine 65 percent solids MUF resin. Resin levels of 7 and 10 percent were used in board manufacture. Four 3 by 7 inch flexure samples were cut from each board; 2 were tested in the normal manner, while the remaining 2 samples were subjected to accelerated aging tests.

Boards made with the fortified urea resin (levels of 20 and 40 percent melamine resin) failed the test. The samples expanded to double their normal thickness and fell apart. Samples made with the melamine-urea formaldehyde resin held together through six cycles of aging, but the strength retention was negligible.

Experiment 3: Evaluation of powdered two-stage phenol formaldehyde resins (Novolak) in durable particle board. Particle boards were made with 8 percent solids of several novolak and UF/novolak blended resins. Two sections from each board were subjected to aging tests. All sections failed. Original physical properties were poor, and generally poor boards were made with these resins.

Experiment 4: Evaluation of a lignin-modified phenol formaldehyde resin in durable particle board. Particle boards were made with two types of chips (white pine splinters and black willow flakes) with 7 percent solids of cascophen X 405–21 (42 percent solids liquid PF), 25 percent of the total resin solids being replaced with a

pulverized lignin product. Several press times (15, 20 and 25 minutes) were used for each chip type. Control boards were made with 7 percent solids of the unextended resin at a press time of 20 minutes. Four 3 by 7 inch flexure samples were cut from each board; 2 were tested as controls and the other 2 were subjected to 6 cycles of accelerated aging prior to testing.

The physical properties, that is, flexure and internal bond values, were inferior to those of the control boards. This loss in strength was greater than the savings effected by using the low-cost lignin to replace resin solids. All samples exposed to aging tests retained less than the required 50 percent of their original strength. The lignin-extended resin (versus unextended resin) was the poorest in this respect. This resin either unextended or lignin extended is unsuitable for use as a durable binder.

West Coast Research

The particle board industry on the west coast has been using phenolic resins in boards for sometime. A number of adhesives have therefore been explored, as well as modifications of phenolic resins. It has been difficult, however, to settle on a standard test. One practical approach has been to submit the board to the same boil test as required for Douglas-fir plywood. If 50 percent of the original modulus of rupture strength is retained after a 4-hour boil, dry 20 hours at 145°F., 4-hour boil test, the adhesive or board may be considered suitable for exterior applications. Perhaps other physical property tests such as internal bond, screw-holding, and others should be conducted.

A few experiments performed in the Borden particle board laboratory at Seattle are cited as follows:

Experiment 1: Determine how to improve lack of phenolic resin binders as used in particle board applications. Good tack is obtained with urea resins. However, phenolic resins tend to produce a dry, flaky mat. Various phenolic resins were modified with gums, wheat flour, and a polyvinyl acetate. The pre-pressed mat characteristics were noted and the physical properties of the finished board were compared. Air drying appeared to eliminate any tack resulting from the gums or flour. Polyvinyl resin improved the tack. A viscous resin will improve tack; wax reduces tack. At least 1 percent wax appeared necessary for the best boil and water resitance.

Experiment 2: Effects of adding an organic extender to a phenolic resin used in making particle board. Some work done recently has indicated that manufacturing costs of phenol-formaldehyde resins can be reduced and properties maintained if up to 50 percent of the phenol is replaced by an equivalent amount of an organic extender prior to condensing the resin. A resin was made on this order and evaluated with Douglas-fir hammer-milled chips. The results were interesting when compared cost-wise to past work performed with a conventional urea formaldehyde resin. A comparative run was also made with a standard phenolic particle board resin with the extender added after manufacture. Results indicated that, in order to have comparable strength at equal binder cost based on an M.O.R. test, the density of board would need to be as follows:

Control Board Urea-F	40	lbs.
Phenol-F-Extender reacted into resin	42½	lbs.
Phenol-F resin	45	lbs.
Phenol-F resin-extender —admixed	48	lbs.

Experiment 3: Observe the effect of Shell Chemical Corp. insecticide dieldrin on particle board made with a urea-formaldehyde resin and a phenol-formaldehyde resin. Four series of particle boards were run with each resin. They consisted of three levels of Dieldrin and a blank for each resin. Flexural strength and dimensional stability tests were run, as were tests to determine the dosage required to prevent attack by drywood termites as well as subterranean termites. The maximum dosage of 0.5 percent (based on resin solids) did not affect the physical properties, and it was very effective in preventing attack or penetration by insects.

Looking Ahead

Where do we go from here? We have presented a picture of how durable particle board has been made on a laboratory basis and the degree of durability obtained.

We are aware of some of the problems and have made resins that make possible the production of boards, with greater durability than the boards in common use at present. Work to achieve further improvement in durability, at economical costs, is continuing. If success is obtained in converting plants to phenolic resin, the potential demand could create a need for more board than the capacity for all present and contemplated plants.

What do production managers of particle board plants think about using a more durable resin? What do Sales Managers think of selling a more durable board? What are the markets? What are the real requirements or needs that are not available in present products? The answers may be provided soon—some of the indications are encouraging. These are evident in the demand created in the building field for lower cost, suitable replacements for lumber. Some of this demand is being filled by plywood sheathing, exterior plywood, and insulating building board. Current prices of these products that a more durable board will most likely be competing with are compared as follows:

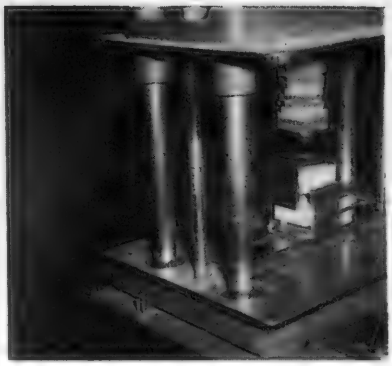


Fig. 4.—Cross-lap specimens in test.

Prices/M sq. ft. East Coast

4 x 8 Panels	Retail	Yard cost	Mill price
5/8" Sheathing DF-CD Interior	$187	$117	$ 92
5/8" Exterior Plywood DF-AB	296	185	163
5/8" Particle Board (P-F Bond)	369	231	170
5/8" Particle Board (U-F Bond)	337	211	150
½" Insulating Building Board	100	80	66

Some of the advantages of promoting a phenolic-bonded particle board are as follows:

1. Eliminate problem of deterioration, which affects acceptance of present urea formaldehyde board in many volume markets.
2. Fire underwriters would give the board a better rating, which would open new markets.
3. The farm market would be opened, which constitutes a potential as great as housing.
4. Building codes would recognize the product, and thereby increase sales.
5. Acceptance by F.H.A. for more uses in home buildings would increase sales.

When the industry produces a product with physical properties suitable for application in these markets, at a competitive cost, tremendous outlets are there to be filled. Chemical suppliers are prepared to supply more durable adhesives that will enable particle board producers to made more durable products and meet this need. The economies depend on the quality of board, and this depends upon specifications set up by consumers, manufacturers, and trade associations. A cooperative effort will increase the markets for all.

Burma

The first plywood plant to be set up in Burma has gone into production. The plant, which was imported from Japan, has been established by a leading Burmese timber operator. Its present production is 850 sheets of plywood, 4 feet by 8 feet, per day with unskilled labor. As this labor becomes more skilled, it is anticipated that daily output will be considerably increased. A contract has already been made for the supply of 50,000 sheets of plywood, valued at kyats 10 lakhs (U.S. $21,000), to a West German firm.

The introduction of plywood plants in Burma, as well as other new forest utilization industries, was recommended by FAO expert, J. A. von Monroy, who carried out an assignment some years ago to advise on the development of integrated forest industries in Burma.

Sudan

The Forest Department is running 11 sawmills and 22 hand sawing camps. The production of sawn timber during the last three years is reported to have been as follows:

	Cubic feet	*Cubic meters*
1955–56	405,000	11,500
1956–57	638,000	18,000
1957–58	790,000	22,400

The main species utilized are *Acacia arabica, Isoberlina doka, Khaya senegalensis, Khaya grandifoliola, Podocarpus melinjainus. Afzelia africana,* and *Danielia oliveri.* The progressive increase in the volume of sawn timber is due to improvements in the sawmills, reduction of waste and improved extraction equipment.

Thailand

Through FAO technical assistance and with the completion of the new laboratory at Bangkhen, it has been possible to install one pilot drying kiln, one pilot preservation plant, one small plywood plant, a set of woodworking machines, and two timber strength-testing apparatus. The laboratory is ready to begin some fundamental research work in the field of wood technology.

Argentina

The government-operated railroad company in Argentina is reported to have signed a five year contract with a local firm at Santiago del Estero for preservative treatment of 2.5 million wooden sleepers of quebracho blanco (*Aspidosperma quebracho-blanco*) at an approximate cost of U.S. 22 cents each.

WORLD-WIDE Forest Products News

Liberian Foresters Visit National Executive Office

Left to right: J. I. Reeves, W. W. Cooper, and Gustave Barshefsky.

The National Executive office was honored by a visit from two foresters from Monrovia, Liberia.

Messers. Reeves and Cooper were on an extended tour of U.S. industrial and governmental plants and research institutions under the auspices of the ICA.

In their home, they are attached to the Bureau of Forest Conservation, Department of Agriculture, Monrovia, Liberia.

While here, Mr. Reeves and Mr. Cooper visited with FPRS member Gus Barshefsky, 5315 N. Bernard St., Chicago, Ill.

New Zealand

The pulp and paper industry now comprises three integrated units producing sawn timber, chemical and mechanical pulp, paper and paper board. There are two plants producing paper and tissues from purchased raw materials, imported and home produced.

Plans for further expansion are in different stages of preparation and it is expected that newsprint and kraft paper production will have doubled by 1965. Present production figures are 90,000 tons of mechanical pulp; 120,000 tons of chemical pulp; 65,000 tons of newsprint; 38,000 tons of other paper; 28,000 tons of paper board; and 21,000 tons of fibreboard.

Construction of the first wood particle board plant has been completed and consideration is being given to establishing a second one.

Import restrictions on steel and imported timbers have given added impetus to the use of radiata pine in glued laminates for constructional purposes. Already several buildings employing glued laminates have been erected and great interest is being shown by engineers and architects.

Scanning World Wide Forest Products Publications

Germany

Different Main Drives on Veneer Slicers. Ernst Grofhennig. *(In German) Holz Als Roh–Und Werkstoff, Vo. 17, No. 4.*

Presents results of an investigation of the main features of electro-magnetic reversible drives, oil-hydraulic driving aggregates, and crank drives. Performance attained and power requirements are presented. Improvement of these data are considered possible in case of corresponding tests in practice.

Investigations on Belt Sanding of Wood with Straight Cutting Movement. G. Pahlitzsch and K. Diziobek. *(In German) Holz Als Roh–Und Werkstoff, V. 17, No.4.*

Tests have been made on a special belt sander to study some relations in wood sanding. Specimens of spruce, pine, poplar, alder, red beech, oak, and teak wood have been used as test material. The influence of various factors has been investigated by determination of the volume of abrased wood and the main cutting force. direction of fibre, size of sanding area, belt speed, pressure, and grit sizes.

Results: The volume of abrasion is influenced by structure, strength, and wood extractives and increases with sanding perpendicular to the grain. With constant pressure, volume of abrasion increases in proportion to reduction of sanding area. The optimum belt speed as determined by the specific quantities of abrasion is 30 m/s for grit size 120. The influence of grit size is mainly determined by smaller volumes of abrasion for finer grits and higher sensibility against high pressures.

Our three-point program for

BEST UTILIZATION OF AMERICA'S TIMBERLANDS

1. Good management of our forests—by the most advanced tree-farming methods

2. Products research to utilize to the fullest the timber we cut

3. Modern marketing and sales management to balance the demand for products against materials supply—so that "nothing goes to waste"

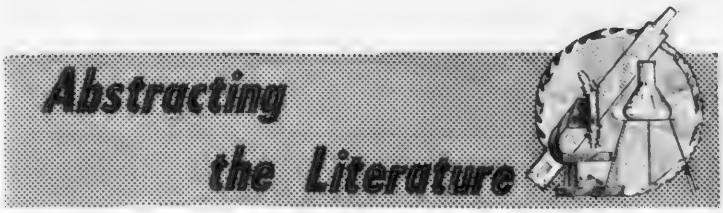
A simple program—simply stated—but it requires vast investments in skilled manpower, lumbering facilities, forest management, research and development laboratories, and modern plants. And—to get the most effective distribution—widespread modern warehousing and sales operation to be sure that our forest products reach markets in every part of the country.

United States Plywood Corporation—40 years old, in 1959—is in business for the future as well as the present.

That is why you will find throughout our organization a dedication to those efforts which will make for the best utilization of America's timberlands.

United States Plywood Corporation

55 W. 44th Street, New York 36, N. Y.



WOOD HYDROLYSIS

Chaloy N. V., and Aleksandrova, O. A. (All-Union Research Inst. Hydrolysis Ind.) The hydrolysis of wood with gaseous hydrogen chloride at atmosphere pressure. Gidroliz. i Lesokhim. Prom. 12, no. 1: 14–18 (1959). [Russ.]

Pinewood chips 3 mm. in diam. and contg. 72.42% potential sugars (including 19.11% hemicellulose sugars) were hydrolyzed during 6 hr. with gaseous hydrogen chloride *(I)* at temps. ranging from 0 to 50°C. The abs. moisture content of the wood was varied from 12.6 to 184%. The quantity of *I* absorbed by the wood ranged from 18.4 to 170% (based on o.d. wood wt.) and was directly proportional to its abs. moisture content. The amt. of *I* bound physically at the external and internal wood surfaces and chemically by the polysaccharides (as detd. from the difference between the amt. absorbed by moist wood and that absorbed by pure water) was indep. of the moisture content but changed with temp. Thus it can be assumed that the plant tissue polysaccharides are hydrolyzed by the hydrochloric acid *(II)* which is formed in moist wood satd. with gaseous *I*. The yield of sugars was found to depend on both moisture content and temp. It was max. at 20° and directly related to moisture content. Hydrolysis below 20° apparently results in products having a rel. high D.P., whereas above 20° the reduced concn. of *II* is the limiting factor. Complete hydrolysis of wood polysaccharides could be achieved only with a *I* consumption of about 150% (based on o.d. wood), the total quantity of water and *I* being 330%, and at temps. not exceeding 25°. Under these conditions, the concn. of *II* within the moist wood was 43.4%. Considering the high consumption of *I* and the high heat evolution during its dissoln., hydrolysis of wood with *I* presents no advantages over the method using 41% *II*, unless a totally new and more economical procedure is developed. 14 ref.

RADIATION AND PROPERTIES

Freidin, A. S. (Central Research Inst. for Mech. Processing of Wood). The effect of nuclear radiation on the physico-mechanical properties of wood. Derevoobrabatyvayushchaya Prom. 7, no. 9: 13–15 (1958). [Russ.]

Samples of pinewood and ashwood contg. 8–10% moisture were irridiated with γ-rays in doses of up to 500 megarep (10^6 roentgen equiv. phys.) from a cobalt^{60} source; two weeks later (to allow for the irradiation aftereffects), their mech. props. were compared with those of nonirradiated samples. The darkening of color, charac. of irradiated wood, was noticeable at a total dose as low as 5 megarep. At 100 megarep the wood became brittle, and at 200 megarep it became easy to pulverize. The resistance of irradiated wood to static bending decreased by 20, 69, and 90% at 50, 200, and 500 megarep, resp. Its shear resistance (in the radial direction) was lowered by 24% at 50 megarep and by 54% at 200 megarep, but its compression strength (along the fibers) was rel. slightly affected: at 500 megarep, it was 66.5% of that in control samples. The irradiated samples absorbed more water but less water vapor than the control samples. A statistical anal. of the exptl. data showed that the coeff. of variability increased with increasing total irradiation dose 8 ref.

WOOD CHEMISTRY

Rudakoy, G. A. (Central Research Inst.) Material for industrial synthesis. Gidroliz. i Lesokhim. Prom. 12, no. 1: 4–6 (1959). [Russ.]

The utilization of wood turpentine as a starting matl. for the synt. of a variety of products (camphor, insecticides, styrene derivs., cyclic alcs. and dibasic acids, peroxides, etc.) is discussed. At present, only camphor and terpineol are produced in Russia on an ind. scale, mainly from turpentine obtained by tree tapping. However, the realization of the planned expansion of the kraft pulp ind. will soon make available a large quantity of sulfate turpentine and tall oil which can be utilized for the synt. of terpene derivs. and as rosin size substitute, resp. 23 ref.

HYDROLYSIS WITH X-RAY

Sharkov, V. I., Korol'kov, I. I., and Krupnova, A. V. (All-Union Research Inst. Hydrolysis Ind.)The conversion of pulp and wood into readily hydrolyzed materials under the influence of γ-rays. Gidroliz. i Lesokhim. Prom. 11, no. 8: 3–4 (1958). [Russ.]

Sprucewood sulfite pulp, sawdust, and LC (obtained by mild hydrolysis of wood) were irradiated with 10^7, 10^8, and 10^9 r. units of γ-rays. Samples that received the highest radiation dose were converted into a dark-colored powder partly sol. in water, but at lower doses no changes were observed in the appearance of the matls. The irradiated samples were hydrolyzed at 180° C. with 0.1 *N* sulfuric acid, and detns. were made of their hydrolysis rate and yield of reducing substances (expressed as percentage of total carbohydrate content). Samples irradiated with 10^7 r. gave a max. yield of 43–45% in about 60 min., i.e., the same as control samples, whereas samples irradiated with 10^8 and 10^9 r. gave yields of 62–63.5 and 68.3–725% in 30–35 and 6 min., resp. The hydrolyzates contained about 81% fermentable sugars, indicating that irradiation caused no significant changes in the structure of glucose mols. Wetting of the cellulosic matls. with 0.1 *N* ferrous sulfate intensified the effect of γ-rays. Thus, irradiation with 10^8 r. in the presence of ferrous sulfate resulted in a sugar yield of 68–69%, and 10^9 r. caused blackening of the wood and a reduced sugar yield. 3 ref.

WOOD PYROLYSIS

Katunin, V. Kh. (Central Research Inst. Wood Chemistry), and **Filippov, B. N.** (Amzinsk Wood Processing Plant). The condensation of volatile wood pyrolysis products in a foam-type condensing apparatus. Gidroliz. i Lesokhim. Prom. 12, no 3: 5–7 (1959). [Russ.]

A foam-type (direct-contact) condenser for the recovery of volatile wood-pyrolysis products and their sepn. from noncondensing gases is described. In this app., the foam layers through which the gaseous mixt. passes is formed on the upper and lower grids during the turbulent mixing of the gases with the condensate fed into the app. by means of a pressure pump. The advantages of the app. over the surface- and spray-type condensers, such as compactness, high condensing efficiency, and the elimination of entrainment losses caused by mist formation, are pointed out. 2 ref.

ECONOMICS

Pikl, Ignatz James, Jr. Economic problems of pine pulpwood production in the South and in the Hiwassee region. Ph.D. Thesis. Vanderbilt Univ., 1958. 505 p. [Microfilm] Dissertation Abstr. 19, no. 8: 1940 (Feb., 1959).

A study of the recent history and the economic problems of the southern U. S. pulp and paper ind. and the pine pulpwood ind., particularly in the Hiwassee region, was made to test the hypothesis that the growth of the pine pulpwood ind. in this region—no longer threatened by stumpage shortages—may instead be limited by migrations of the rural population to ind. centers in the South and to places outside the South. This hypothesis was found to be invalid, at least for the region studied.

SOURCES OF FPRS ABSTRACTS

The preparation of abstracts from the world literature is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts used in the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles. Copies or additional information can not be supplied by FPRS or the abstract journal.

BRI ABSTRACTS OF BUILDING SCIENCE PUBLICATIONS, published for the use of its members, by the Building Research Institute, National Academy of Sciences—National Research Council, 2101 Constitution Avenue. Washington 25. D. C.

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin, by the Institute of Paper Chemistry.

CHEMICAL ABSTRACTS. published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL, published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England.

Over 700 "Profit through Research" at FPRS 13th National Meeting

"HOW FOREST PRODUCTS COMPANIES are turning industrial, university and federal research into profits," was the major topic for discussion at the Forest Products Research Society's 13th National Meeting held in San Francisco, June 28–July 3, 1959. Six-hundred and ninety-one persons, 158 of these ladies, were in attendance. A record 20 technical sessions, numerous business meetings and trips to 6 outlying plants and educational institutions were held.

A great amount of fundamental and applied research results, much of it useful to the Pacific Northwest's sizeable timber economy, emerged. Scientists at the University of California's Forest Products Laboratory described how that state's hardwood timber may be moving to step closer to full utilization as a result of experiments with a new method of lumber drying, solvent seasoning. Success could open the way to full utilization of the two-billion-board-foot supply of standing tan oak timber, suitable for flooring and furniture. Other hardwoods currently being discarded because of seasoning defects include black oak and Pacific madrone, totalling 3-billion board feet.

New Finishes for Wood Surfaces

In other research findings, Neil Estrada of Reichhold Chemicals, Inc., reported on new finishes for wood surfaces which have been developed, combining resins and plastics to provide an extremely hard surface and color stability at relatively low cost.

Henry Hill, noted west coast architect, discussed the new concept of space as a prime essential in building design and which is lending new urgency to research on structural uses of wood. "Architects need more information from the wood industry if they are to make the best use of wood in these

General Chairman Raymond H. Berry officially opens 1959 National Meeting.

new space-oriented designs," he said. He called for more understanding and a better program of education and communication between the wood industry and architects. He emphasized that architects cannot tolerate waste, forcing some to go ahead on their own to simplify structural details and cut down the complexities of specifications held over from earlier days.

Nation-wide Wood Promotion

Lumber advertising and promotion no longer suffer by comparison with promotion of other building materials, Sherman A. Bishop, Union Lumber Co. executive, told the gathering. He noted that three west coast trade associations alone are promoting wider use of wood by means of some 20 motion pictures, 23 television programs, and thousands of advertising mats, ads and literature. He urged greater use of such aids by wholesalers and retailers in order to cash-in on the nationwide wood consumer promotion program now in high gear.

Measuring Surface Texture

Precise measurements of wood surface texture may be a key to improved quality and production control in the wood industry, according to University of California researcher Donald A. Stumbo. "Tiny patterns of peaks and valleys, some unseen by the most expert eye, could serve as a guide by reduction of waste and to control of many machining processes," he said. He described two methods for precise surface texture determination: 1) the stylus tracer that magnifies and records the movement of a stylus across the surface, and 2) "light sectioning," employing a source of parallel light cast on the surface at an angle and recorded as a wavy line on a film.

Strength of Particle Board

In another U. of California report, Eugene L. Bryan described how "when you take wood apart and put it back together again as particle board, it is likely that the effect of long-term loading on the material's respective strengths is not appreciably changed," This fact may well help advance the use of particle board as a material for subflooring and other structural uses. Based on tests, he concluded that the behavior of the particle boards tested was similar to solid wood at a moisture content level of 6 percent.

And so the largest technical meeting in FPRS history proceeded, through more than 100 individual presentations in 20 sessions covering five successive days.

Retiring FPRS president W. Jeter Eason, of Nickey Bros., Inc., Memphis, Tenn. expressed it this way. "This meeting has reaffirmed the position of wood as the perfect renewable natural resource. Its diversity proves that the lumber industry's interest in formal research will enable it to realize its full economic potential." He concluded that, "progress and product development for everyday living has marked the entire 350 year history of the wod industry on this continent."

Scene at registration area as 700 register.

Lt. Gen. James M. Gavin addresses Official Luncheon.

Chairmen and Authors of 20 National Meeting Technical Sessions

Session I—Wood Composition Board—Authors, Recorder and Presiding Chairman, A. L. Mottet, far right.

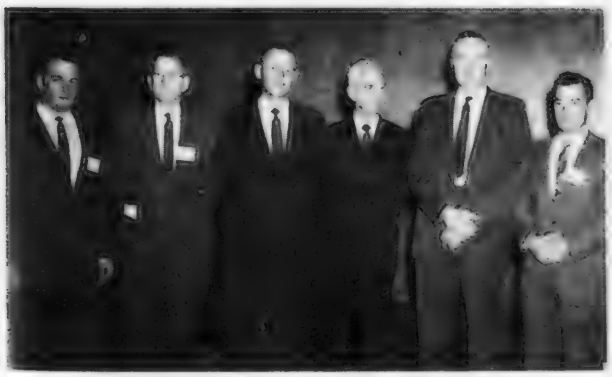
Session II—Veneer and Plywood—Presiding Chairman John F. Lutz, standing in front of lectern with authors and official recorder.

Session III—Wood Machining—Chairman Charles Beroizheimer elicits a spirited discussion between audience and authors.

Session IV—Glues and Gluing—Chairman Richard F. Blomquist standing directly behind lectern introducing various authors and panelists in his Session.

Session V—Chemical Utilization—presiding Chairman E. G. Locke (4th from left) and authors.

Session VI—Wood Preservation (l. to r.) Bill Hopkins, John Fies, Chairman Charlie Walters and two unidentified authors.



Session VII—Logging—Chairman Emanuel Fritz of the University of California (4th from left).

Session VIII—Wood Drying—Extreme left A. P. Schniewind, California Forest Products Laboratory, 1959 Wood Award winner; fourth from left presiding Chairman Eric Ellwood.

More than 100 Authors, Presiding Chairmen, Recorders and Session Aids Conduct 20 Technical Sessions at FPRS' 13th National Meeting

Session XI—Wood Finishing—Attracting the largest number of panelists of any Session of the National Meeting. Presiding Chairman Don Lubeck, Hammond Organ Company, seated extreme left.

Session IX—Wood Finishing—was moderated by Chairman Don Laughnan, U. S. Forest Products Laboratory (shown seated center).

Session X—Lumber Manufacturing (l. to r.) Presiding Chairman Milton Mater. Recorder Paul Heller; authors D. E. Lane, Tom Shelton, Lee Hooker and Herb Winer.

Session XII—Packaging—Shown with authors are second from left Division Chairman A. R. Tegge; third from left Presiding Chairman Karl Bollerslev of Boise-Cascade Corporation.

Session XIII—Lumber Manufacturing and Wood Drying "team up" to present a joint session. Presiding Chairman Paul Heller, Pacific Pine Co., Ltd. seated extreme left. Next to him is John M. McMillen, U. S. Forest Products Laboratory.

Session XIV—Glues and Gluing—Presiding Chairman Ben S. Bryant, University of Washington at extreme left.

Session XV—Industry-Education—Presiding Chairman W. E. Welch, Timber Structures, Inc. stands before lectern flanked by authors.

Session XVI—Merchandising—Chairman W. B. Lloyd, Michigan State University (second from right).

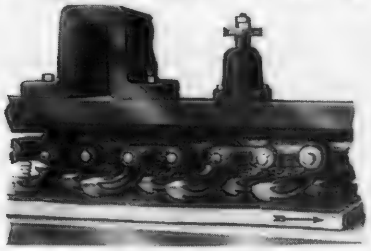
Session XVII—Chemical Utilization—Recorder J. E. Lodewick and Chairman Winton Patnode (seated).

Session XVIII—General—Presiding Chairman R. A. Cockrell, University of California, stands before lectern.

Session XIX—Composition Board—Standing, K. W. Guenther, Eugene Bryan, J. W. McCarthy, George Kitizawa. Seated A. L. Mottet, Bruce Heebink and Walter Ring.

Session XX—l. to r. Robert Gilmore, Chairman A. E. Wylie, O. J. Black, J. R. Stillinger and George Smith.

Finger-Tip Touch!



ELIMINATES SPLITTING — SAVES LUMBER

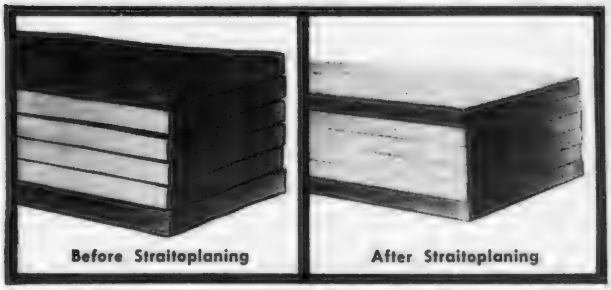
"OLIVER" STRAITOPLANE

planes both sides of warped stock smooth and parallel — at the same time!

In one pass the "Oliver" Straitoplane takes raw stock out-of-wind and planes both sides smooth and parallel — it does the work of a facing planer and a single surfacer. It planes out as much as ¼ inch on each side at speeds up to 90 feet a minute. The bottom side is face jointed, and the top side planed smooth to the desired thickness.

The Straitoplane will plane warped or straight stock simultaneously on both sides up to 36 inches wide, and from ½ to 6 inches thick. It planes both sides of pieces as short as 12 inches when fed continuously, as short as 16 inches when fed singly.

Write today for complete information.



OLIVER MACHINERY COMPANY
GRAND RAPIDS 2, MICHIGAN

Picture Highlights of Social Activities during FPRS 13th National Meeting

Northern California Section represented here by Fred Dickinson served as hosts at a traditional California "wine tasting party" the eve of the National Meeting. Partaking of samples are Past President Jim Hamilton and Glues and Gluing Division Chairman Dick Blomquist.

The traditional "Paul Bunyan Hour" sponsored by some 70 wood industry suppliers was held at the Olympic Country Club where some 547 registrants participated in the festivities.

Shown enjoying the social activities at the Paul Bunyan Hour are Mr. and Mrs. Mark Lehrbas, Charles Lockard and Bob Kuhn.

Enjoying the convivial atmosphere at the Northern California "Host Hour" are Board Member Walton Smith, Executive Secretary Frank Rovsek, Mrs. Rovsek, Board Member James Love and Mrs. Love.

The Madison, Wisconsin and Grand Rapids, Michigan membership was well represented at the Paul Bunyan Hour by members and friends of the Dacar Plastics Corporation, including Mr. and Mrs. George Johnson, Walter Noble and Harold A. Lenderink.

Members of both incoming and outgoing national Executive Boards gather at one of several board sessions held during the National Meeting.

A national membership record was set at the San Francisco meeting when, under the direction of National Membership Chairman T. S. Veazey, Society membership reached almost 4,000. Shown receiving awards for meritorious Section membership activity are (l. to r.) Earl McCarthy representing the Pacific Northwest Section, Membership Chairman Tony Veazey; Harry Russell accepting the first place award for the Mid-South Section; and Executive Secretary Frank Rovsek.

One of the best staffed membership operations of any FPRS National Meeting found Steve Preston, University of Michigan and Bill Hopkins, Louisiana State University discussing membership advantages with prospective members. They were but two of a large committee who worked "around the clock" to reach the membership quota.

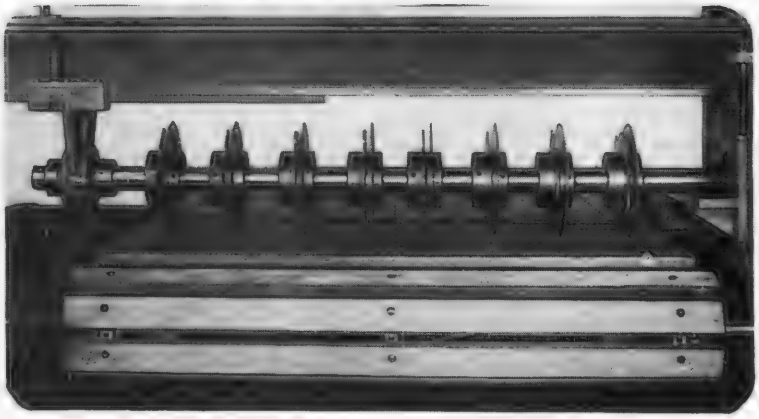
An added attraction of the National Meeting was a breakfast in honor of the distinguished luncheon speaker, Lt. Gen. James M. Gavin, hosted by the Arthur D. Little Company. Officers, board members and many others of FPRS were guests at the event.

Shown at one of the numerous planned ladies' activities were Lois Eason, wife of FPRS's national President, W. Jeter Eason and Steena Berry, wife of the 1959 National Meeting Chairman, Raymond Berry. In all, more than 158 ladies registered for the week-long activities.

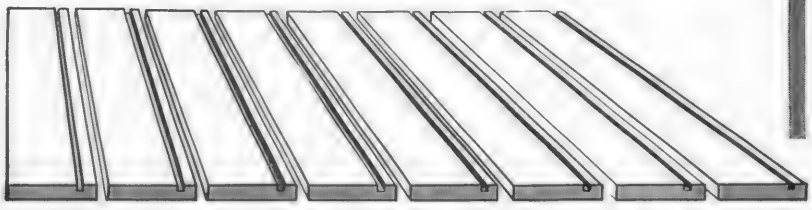
with the **MEREEN-JOHNSON NO. 435-H**

YOU GET ALL 4

MULTIPLE CUT-OFF...
MULTIPLE GROOVER...
MULTIPLE RIP SAW...
EQUALIZER



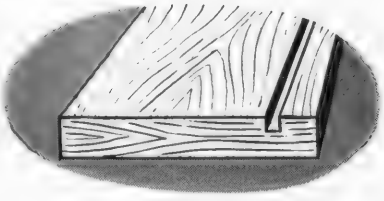
Arbor set-up for multiple drawer front work.

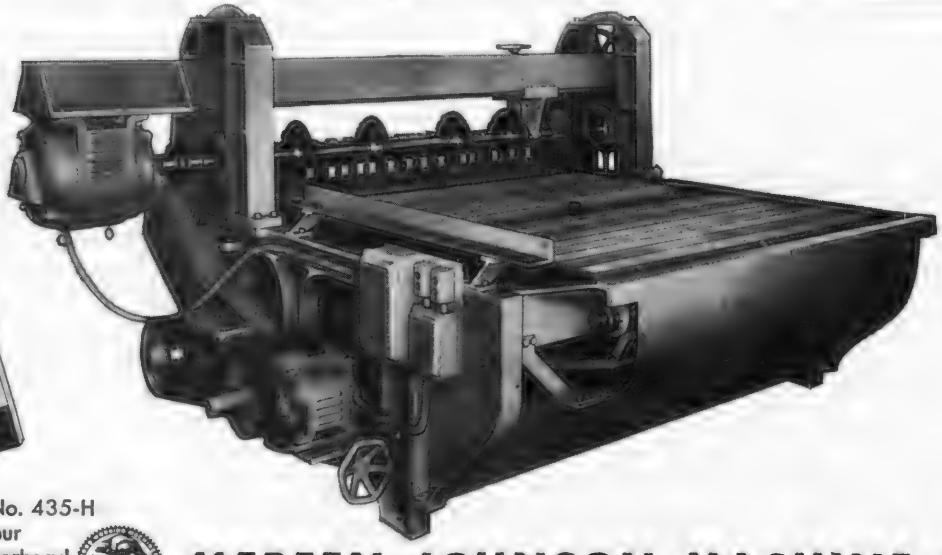


8 identical drawer fronts ripped and grooved in one pass.

THESE 4 are only a few of the uses for the versatile M-J No. 435-H Slat Bed Machine. Installations in furniture factories have proved that this machine will produce parts formerly manufactured on variety saws and by other hand operations. This machine is available in a wide variety of sizes and with practically any number of saws and groovers or saw and groover combinations. It's one of the most adaptable machines ever designed for use in a modern woodworking, plywood or furniture plant.

- **Trims ends of an entire case front, while notching or easing edges of drawer front ends.**
- **Sizes and squares plywood to ceiling and wall squares.**
- **Rips a complete panel into bed rails in one pass.**





For Bulletin No. 435-H inquire on your company letterhead to:

MEREEN-JOHNSON MACHINE CO.

4401 LYNDALE AVE. NO. • MINNEAPOLIS 12, MINNESOTA

CUT-OFF SAWS | DOUBLE CUT-OFF SAWS | MULTIPLE CUT-OFF SAWS | GANG RIP SAWS
TENONERS | VENEER & PLYWOOD SIZERS & JOINTERS | RESAWS

Description of FPRS 13th National Meeting, Cont'd.

Elizabeth Davenport (second from left) welcomes an FPRS registrant.

Registration

Registration began Sunday afternoon, June 28, and was under the direction of Robert M. Kuhn, Chairman of Budget and Finance, assisted by Miss E. M. Davenport, Secretary, and various members of the National Meeting Committee. The registration fee was $12.00 for FPRS members and $14.00 for non-members. This included admission to all sessions, meetings, plant tours and to the Paul Bunyan Social Hour. Ladies' registration fee was $6.00. The official final attendance was 400 members, 73 non-members, 51 one-day attendees, 9 students and 158 ladies, for a total of 691.

Outgoing President W. Jeter Eason acknowledges his appreciation to FPRS for the opportunity to serve as General Gavin and incoming President E. S. Harrar look on.

Official Luncheon

The thirteenth Official Luncheon was held on June 30 in the California and Mural rooms of the St. Francis Hotel. Retiring President, W. Jeter Eason, presided. The invocation was pronounced by Dr. Reavis C. Sproull who said: *"Give us wisdom to use these resources for the welfare of all mankind, in ways which will assure a continuing supply of forest products for the use of future generations."* Honored guests included George Christopher, Mayor, City of San Francisco; Charles A. Connaughton, Regional Forester, Region 5, U. S. Forest Service; A. B. Hood, Vice President, National Lumber Manufacturers' Association; Robert M. Ingram, President, National Lumber Manufacturers' Association; DeWitt Nelson, Director, Department of Natural Resources, State of California; Henry J. Vaux, Dean, School of Forestry, University of California; Dr. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station.

The Guest Speaker was Lieutenant General James M. Gavin, U.S.A. (Ret.), Executive Vice President, Arthur D. Little, Inc. who spoke on "Research in Tomorrow's World".

Mr. Eason then announced the retiring and new members of the national Executive Board. Retiring members included W. L. Irwin, Pickens, South Carolina; R. W. Warner, Warren, Arkansas and Dr. F. H. Kaufert, Minneapolis, Minnesota. New board members were Walton Smith, Asheville, North Carolina; James Love, Diboll, Texas and Col. John H. Jenkins, Ottawa, Canada. Donald K. Saunders, Westbrook, Maine was introduced as Vice President; Raymond H. Berry, Burney, California as President-Elect and Dr. E. S. Harrar as President.

Tenth Annual Wood Award Competition

A paper exploring the cause of wood warpage by Arno P. Schniewind, University of California Forest Products Laboratory, won the first award in the tenth Annual Award competition sponsored by Wood & Wood Products magazine and conducted by FPRS Industry–Education Division. Dr. Schniewind's paper appears on page 350 of this issue.

The second award on the subject of wood adhesion went to Harland G. Freeman, graduate student in the Yale University School of Forestry.

The awards were presented at the Official Luncheon by J. F. Koellisch, Editor and Manager of Wood & Wood Products magazine. Ten entries from nine colleges and universities were submitted.

Awards of Merit Competition

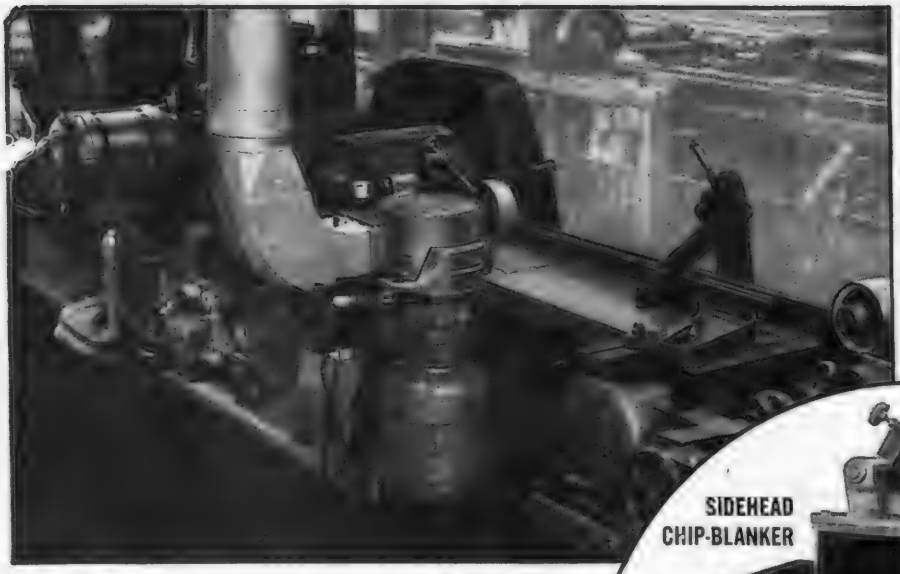
A School of Forestry, Colorado State University; a trade association, Ponderosa Pine Woodwork Association and an industry supplier, Spotnails, Inc., were presented with annual Awards of Merit at the Merchandising Session on July 2 by Hitchcock's Woodworking Digest, Wheaton, Illinois. The awards were made by Robert Bolinder, representing the Digest.

The Ponderosa Pine organization was cited for its work in promoting the use of wood window frames. Professor Harry E. Troxell of Colorado State University received an award commemorating his university's new wood utilization laboratory, the first in the Rocky Mountain area. R. S. Hannah of Spotnails, Inc. received an award for his company's efforts in telling and showing the wood industry how wood products must surpass other material in appearance, function, design, durability and cost.

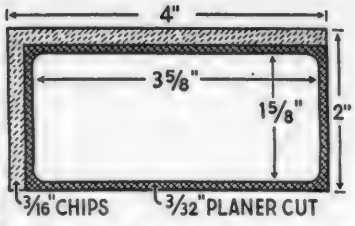
Annual Banquet

The Annual Banquet was held on July 1 in the California and Mural rooms of the St. Francis Hotel and was attended by upwards of 400 guests. The dinner was accompanied by a musical social hour and a subsequent professional entertainment program. A highlight of the banquet was the table decorations of Hawaiian flowers and presentation of leis to many of the distinguished guests through the courtesy of Pan American airlines and FPRS Hawaiian members.

Finely polished wood placards were presented to "Award of Merit" winners during Merchandising Session.



Installation of new sidehead chipblanker unit at MacMillan & Bloedel, Ltd., Somass Division, Port Alberni, B. C.

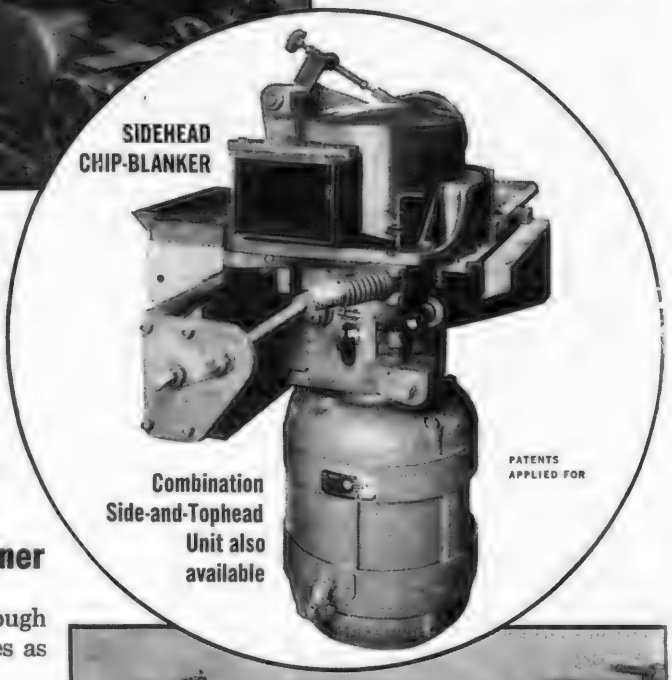


OVER 10% OF GREEN DIMENSION CAN BE SOLD AS CHIPS

Earn...Don't Burn

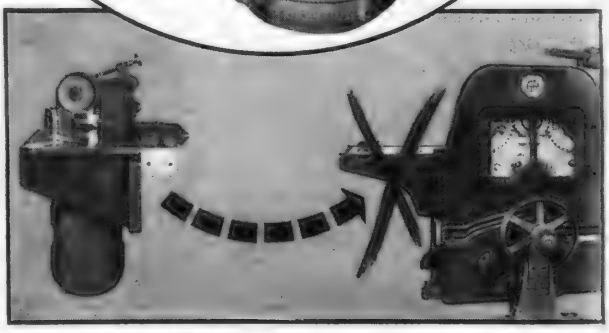
This New MILL-TESTED STETSON-ROSS CHIP-BLANKER

Earns Chip-Dollars Through Your Planer



In normal green-planing 20% or more of each rough board becomes shavings—a waste which increases as "cost", when you consider burner expense.

Now, after 3 years of intensive engineering and planing-mill tests, this new STETSON-ROSS Chip-Blanker has *proved* its ability to earn substantial increased revenue for lumbermen while reducing the cost of shaving disposal.



1. The STETSON-ROSS Chip-Blanker removes excess lumber thickness and width in the form of *marketable chip-sized* bites.
2. It eases the load on your planer-matcher, increases the production rate and reduces the frequency of grinding and jointing.
3. It improves the quality of your lumber because evenly-wide, evenly-thick blanks are fed to the finishing cylinders and side-heads.
4. The STETSON-ROSS Chip-Blanker is easy to install and is adaptable to *all makes* of planer-matchers.
5. In most mills the STETSON-ROSS Chip-Blanker will earn its cost in a few months.

Lumbermen are invited to send for detailed information on this important new source of added profits.

STETSON-ROSS MACHINE COMPANY INC.
SEATTLE 4, WASHINGTON

EXPORT DIVISION, 301 CLAY STREET, SAN FRANCISCO, CALIF

86 Suppliers Host Traditional FPRS "Paul Bunyan" Social Hour

Some 547 registrants and their families attended the 1959 Paul Bunyan Hour event held at the Olympic Country Club. The original cruise of the "Harbor King" and the "Harbor Queen" boats on San Francisco Bay was cancelled at the last moment because of a strike on the waterfront. However, as it turned out the afternoon was overcast and the registrants were delightfully entertained in the spacious and "posh" country club.

The wood industry suppliers who served as hosts to FPRS registrants were:

Allis–Chalmers Manufacturing Company, Oakland, California
American Cyanamid Company, Chicago, Illinois
American Manufacturing Company, Tacoma, Washington
American–Marietta Company, Seattle, Washington
American Sheet Metal Works, Inc., Portland, Oregon

F. E. Barnett Company, Eureka, California
E. J. Bartells Company, San Francisco, California
J. H. Baxter & Company, San Francisco, California
Behr–Manning Corporation, Troy, New York
Black Brothers Company, Inc., Mendota, Illinois
Booth Kelly Lumber Company, Springfield, Oregon
The Borden Company (Chemical Division), New York, N.Y.

The Carborundum Company, Niagara Falls, New York
Catalin Corporation of American, New York, New York
Chain–Belt Company, Berkeley, California
Chapman Chemical Company, Memphis, Tennessee
Cheney Stud Company, Willits, California
Cleworth Publishing Company, Cos Cob, Connecticut
C. K. L. Machinery Company, Oshkosh, Wisconsin
Coe Manufacturing Company, Painesville, Ohio
Collins Pine Company, Chester, California
The Crossett Company, Crossett, Arkansas
Crown Zellerbach Corporation, San Francisco, California

Decar Plastic Corporation, Middleton, Wisconsin
Diamond–Gardner Corporation, Chico, California

Henry Disston Division, H. K. Porter Company, Inc., Philadephia, Pennsylvania
Douglas Fir Plywood Association, Tacoma, Washington
The Dow Chemical Company, Midland, Michigan
Durez Plastics Division, Hooker Electro chemical Company, North Tonawanda, New York

Fairhurst Lumber Company, San Rafael, California
Fiberboard Paper Products, Inc., San Francisco, California
J. J. Fitzpatrick Lumber Company, Madison, Wisconsin
Charles A. Fowler Company, San Francisco, California

Gamble Brothers, Inc., Louisville 9, Kentucky
Goodman Lumber Division, Calumet & Hecla, Inc., Goodman, Wisconsin

Hitchcock Publishing Company, Wheaton, Illinois
R. Hoe & Company, Inc., Portland, Oregen

Ivory Pine Company, Dinuba, California

Koppers Company, Inc., (Chemical Division), Pittsburgh, Pennsylvania

The Lilly Company, High Point, North Carolina
L–M Equipment Company, Portland, Oregon
C. M. Lovsted & Company, Inc., San Francsico, California

Masonite Corporation, Chicago, Illinois
Mater Machine Works, Corvallis, Oregon
Mattison–Greenlee Service Corporation, Rockford, Illinois
Mereen-Johnson Machine Company, Minneapolis, Minnesota
Michigan–California Lumber Company, Camino, California
Monsanto Chemical Company, Seattle, Washington
Moore Dry Kiln Company, North Portland, Oregon

National Casein Company, Chicago, Illinois
National Lumber Manufacturers Assn., Washington, D. C.
Nelsonite Chemical Products, Inc., Grand Rapids, Michigan
Nicholson Manufacturing Company, Inc., Seattle, Washington
Nickey Brothers, Inc., Memphis, Tennessee

Orton Machine Company, San Francisco, California

Pacific Coast Company, San Francisco, California
The Pacific Lumber Company, San Francisco, California
Pacific Manufacturing Company, Santa Clara, California
Perkins Glue Company, Lansdale, Pennsylvania
Peter Cooper Corporation, Gowanda, New York
Poinsett Lumber Manufacturing Company, Pickens, South Carolina
Potlatch Forests, Inc., Lewiston, Idaho
Protection Products Manufacturing Co., Kalamazoo, Michigan

Rader Pneumatics, Inc., Portland, Oregon
Rees Blow Pipe Manufacturing Company, Berkeley, California
Reichhold Chemicals, Inc., Seattle, Washington
Roddiscraft, Inc., Arcata, California

Scott Lumber Company, Burney, California
Sel–Set Machinery Corporation, Salem, Oregon
Setzer Forest Products, Sacramento, California
Simond Saw & Steel Company, Fitchburg, Massachusetts
Simpson Timber Company, Seattle, Washington
Ralph L. Smith Lumber Company, Anderson, California

Southwest Lumber Mills, Flagstaff, Arizona
Standard Oil Company of California, San Francisco, California
Sumner Iron Works, Everett, Washington

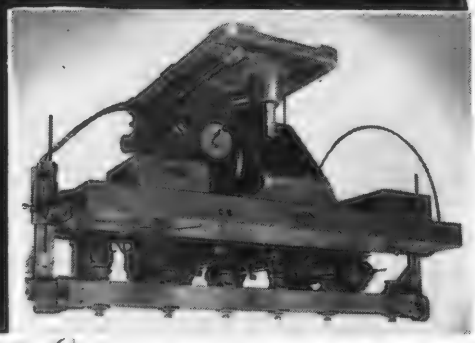
Tarter Webster & Johnson, Inc., San Francisco, California

Union Oil Company of California, San Francisco, California
U. S. Plywood Corporation, New York, New York
U. S. Plywood Corporation, Redding, California

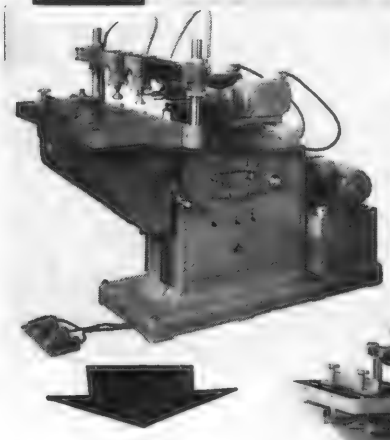
Washington Iron Works, Seattle, Washington
West Coast Lumbermen's Association, Portland, Oregon
Weyerhaeuser Timber Company, Tacoma, Washington
Wilco Machine Works, Memphis, Tennessee
Williams Patent Crusher & Pulverizer Company, St. Louis, Missouri
Winton Lumber Company, Martell, California

ROOT HORIZONTAL BORERS

FEATURE ENGINEERED to MEET WIDE RANGE of REQUIREMENTS

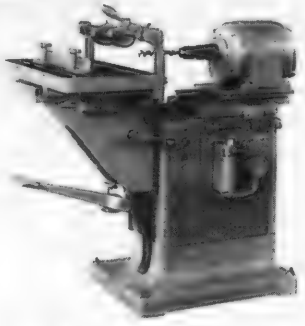


Style D-200 has highly flexible hydraulic feeds —bores holes in multiples in edge, ends or face of stock.

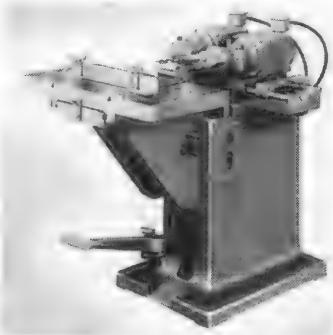


◀ Style D-170 has hydraulic feed for either automatic continuous or intermittent operation—many other features.

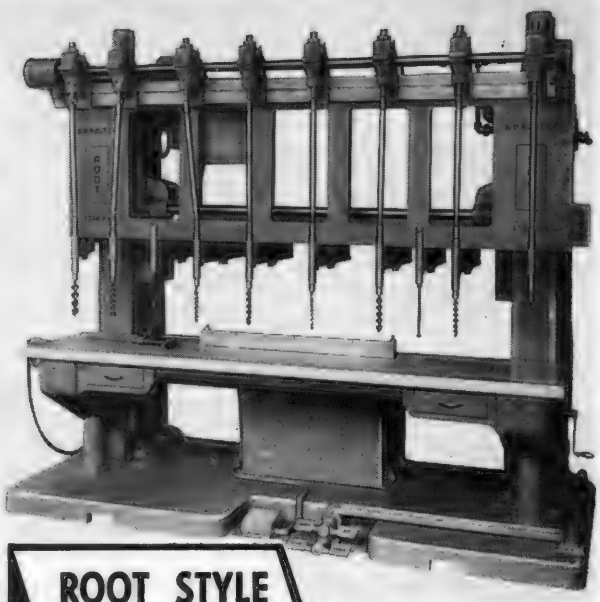
Root Horizontal Borers include machines that provide combinations of features to meet, with the greatest economy and efficiency, just about every type of screw hole, dowel hole and similar boring operations. From foot and hand feed to the newest hydraulic feeds — from single spindle to multiple spindle design with all spindles directly motor driven—for in-line or staggered hole boring—for versatility, ease of operation, maximum productive capacity — whatever your requirements there's a Root Horizontal Borer that's feature engineered exactly to your needs. Write for full information on Root Horizontal Borers —no obligation.



Style DM has direct drive electric spindle, 2 speed motor, hand or foot treadle feed.



Style D-150 hand and foot feed, has two direct drive spindles with radial heads.



ROOT STYLE CFH VERTICAL, DOUBLE COLUMN MULTIPLE BORER *has* NEW AND EXCLUSIVE FEATURES

- **SPINDLES FEED TO WORK TABLE**—with table stationary machine is ideal for use with conveyor set-ups.
- **HYDRAULIC FEED**—Root's patented feed system provides fully automatic or semi-automatic operations.
- **DOUBLE END CYLINDERS**—two hydraulic cylinders assure even pressure to move spindle frame.
- **UNIVERSAL SPINDLES**—up to 26 spindles adjustable along length of frame and 14" crossline spread.

The CFH may be set for either fully automatic or semi-automatic operation, and adjustable over a wide range of feed speeds, depths of stroke, and hole patterns. The machine runs exceptionally smooth and with great accuracy due to a unique floating-balance feature of the spindle rail frame.

Maximum boring area in front of machine's columns is 8'-6" x 14"; between columns 6'-6" x 14". Maximum distance from spindle noses to table is 22¼". Table has a 14" vertical adjustment.

• Write today or descriptive bulletin No. 205—no obligation

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

B. M. ROOT Co.

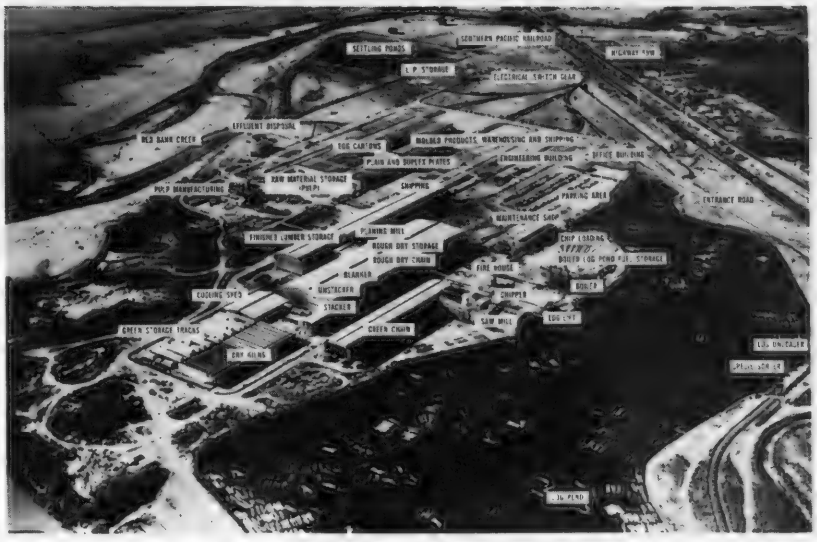
YORK – PENNA.

National Meeting Registrants Tour California Wood Plants

An important feature of the Thirteenth National Meeting was the schedule of visits to a variety of wood industry plants and laboratories, under the direction of Tom Shelton of the Diamond Gardner Corporation.

On July 2, groups visited Fibreboard Products Corporation, Antioch; Michigan–California Lumber Company, Camino; and the University of California Forest Products Laboratory, Richmond. An all-day trip on July 3, included Union Lumber Company, Fort Bragg; Masonite Corporation, Ukiah; and the Diamond Gardner Corporation, Red Bluff.

Advance sign-up during the meeting was required and a charge was assessed to cover the cost of transportation on all trips.



Aerial View of new multi-million dollar integrated forest products plant at the Diamond Gardner Corporation, Red Bluff.

Pulp and Containerboard Mill

Visitors to the Fibreboard Products Corporation at Antioch viewed the principal products of this company,—containerboard, and sulfate and semi-chemical pulp being produced. Most of the raw material arrives at the mill in the form of chips, which have been produced at various sawmills in California from mill residuals. Raw materials consist of Douglas fir, ponderosa and sugar pine, white fir, and some eucalyptus.

Pine Lumber Mill

The Michigan–California Lumber Company, Camino, located in the heart of the Sierra pine region, has been in operation since about 1888. The company owns 85 thousand acres of timberlands and has always been interested in long-term aspects of forest management. The mill at Camino, built in 1950, operates on a one shift basis the year around, producing approximately 45 million feet of lumber yearly.

California Forest Products Laboratory

The largest attendance was to the University of California Forest Products Laboratory, located in Richmond, just across the bay from San Francisco. Here, Dr. F. E. Dickinson and his staff of two dozen scientists direct a research program covering both chemical and physical aspects of wood utilization of California's timber resource.

Redwood Region

The trip to the Union Lumber Company's operation at Fort Bragg offered a unique opportunity for FPRS registrants to travel through redwood forests and along the scenic Mendocina coastline. Here, they visited one of the large redwood operations, over 171 thousand acres of redwood and Douglas fir timberlands, managed on a sustained yield basis.

A load of redwood logs (5 to 6 feet in diameter) ready for transport to the Union Lumber Company mill at Fort Bragg. Load scales 17,000 bd. ft. (Humboldt scale).

Masonite Plant

To many of the registrants, the trip to the Masonite Corporation, Ukiah, was the highlight of the plant tours.

Dr. F. E. Dickinson addressing FPRS visitors.

Several groups inspecting the testing and processing unit at the UC Laboratory.

Why the *strongest* molded-wood articles so often have Durez resins in them

Whack . . . but no crack! When you see a molded-wood product that's *extra strong*, you can be pretty sure it's bonded with phenolic resin.

Why? Because phenolics give strength and durability few other resins can. That's an important point to consider—whether you're making croquet balls, toilet seats, or core stock.

Low moisture absorption and *heat resistance* are two additional good reasons for thinking about phenolic. If moisture and heat are warping the quality of your product, a switch to stable phenolic resins may be the answer.

If you're like a great many phenolic users, you'll specify a *Durez* phenolic. You'll find you can count on uniformity, drum to drum and month to month —because Durez makes its own raw materials and so can control quality tightly.

You'll avoid many processing headaches by taking advantage of Durez technical help. It brings 38 years of resin development and molding application into your plant without a penny of extra cost. If you'd like more information on Durez resins for bonding wood particles, just drop us a note.

DUREZ PLASTICS DIVISION

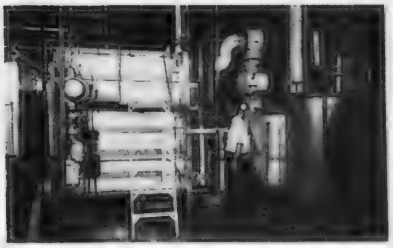
9910 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Turning a huge redwood cant on one of the headrigs of the Union Lumber Company sawmill.

Left to right: Francis Whipple, Crown Zellerbach Corp.; Eric Anderson, N.Y. State College of Forestry; and Fred Dickinson, University of California, discuss wood-texture evaluation.



Experimental solvent seasoning unit at the UC Laboratory. Watson Fearing (center) is one of the researchers testing the new process.

One of the two largest hardboard producing plants in the world, the Ukiah operation demonstrated a completely integrated hardboard manufacturing operation—70 thousand acres of tree farm consisting of redwood and fir timber. The visitors saw how chips are converted into fiber and the fiber, in turn, converted into hardboard on two separate but integrated manufacturing lines.

Top Public Relations "Team Effort" in F.P.R.S. National Meeting History

The Publicity Committee for the National Meeting under the direction of Fred E. Dickinson of the University of California and W. E. Pratt of the California Redwood Association, assisted by staff member Jack Hayes, California Redwood Association; Bob Craig, Western Lumber Manufacturers, Inc.; Bob Jordan, American Forest Products Industries, Inc., set up one of the most professional publicity staffs that any technical society could hope to have working for it on a national meeting. Prior to the meeting for a full year periodic newspaper, radio and television releases went forward to media in lumber areas of the west coast and throughout the nation. News briefs, short news releases and abstracts were written and released ahead of the conference covering more than 40 of the technical papers. Invitations were mailed to editors or technical writers of newspapers and business magazines. The opening press reception attracted several trade publication writers as well as reporter-phtographer teams from the San Francisco papers. Key FPRS officials and wood products spokesmen were on hand for personal interviews.

The news conference held Tuesday, June 30, in honor of General Gavin attracted 17 newspaper, wire service, radio, television and magazine reporters.

The official meeting press room functioned for four consecutive days. One to four persons were on duty at ll times. Assisting with the operations were Ray Colvig, University of California; Clyde Walker and Ernie Draves of the U. S. Forest Service.

Air Lift to Diamond Gardner

The lumbermen delegates to the meeting were impressed with the new Red Bluff plant of the Diamond Gardner Corporation, representing an investment of more then $25 million. Recently completed, it includes a completely integrated operation with sawmill, pulpmill, and molded pulp plant. Visitors viewed a sawmill designed to handle logs from 6 inches to 6 feet in diameter and able to process 90 million board feet of lumber annually. They saw residuals from the sawmill chipped and sent to the pulp plant for pulping and manufacture into molded pulp articles.

Meet the Ladies Committee. Back row (left to right): Ruth Smith, Lillian Ericksen, Dorothy Ellwood, and Louise Smith. Front row (left to right): Co-chairmen Marie Roth and Barbara Kuhn, Liz Pratt and Doris Dickinson.

The ladies' program, so ably planned by Co-chairman Marie Roth and Barbara Kuhn, entertained 158 ladies during a delightfully cool and sunny week in San Francisco. The first of many exciting events, was the traditionally-Californian "Wine-Tasting Party" held Sunday evening at the St. Francis Hotel, and hosted by the Northern California Section.

Monday's program began with a get-acquainted Kaffeeklatsch in the morning followed by a scenic bus tour of the fabulous city that afternoon. On Tuesday a Continental breakfast preceded a tour of some of the city's loveliest shops, giving the ladies a behind-the- scenes glimpse of such exciting shops as I. Magnin, Gump's with its fabulous Jade collection, and Podesta Baldocci, America's most famous florist.

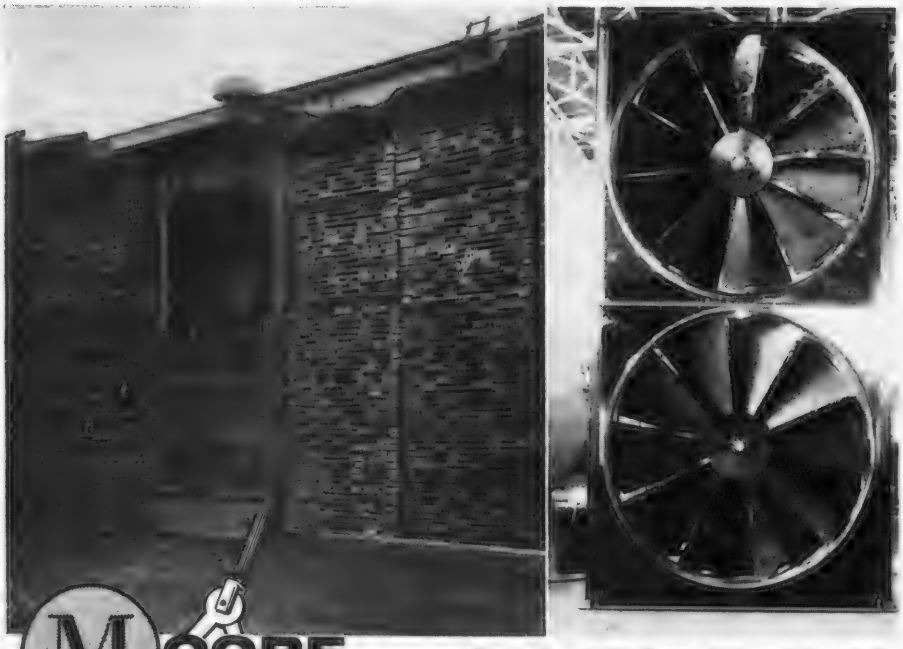
Then on Wednesday noon the ladies assembled at the Canterbury Hotel's Garden Court, a veritable oasis, for a Luncheon and Style Show. And on Thursday afternoon they toured historic Jackson Square, the world's most unique decorative center. These buildings, once the bustling vortex of San Francisco trade in the Gold Rush Days, have been restored to be the elegant wholesale showrooms of more than 70 firms displaying fabrics, wallpapers, furniture, floor coverings, decorative accents, and art treasures from across the world.

Periods of time throughout the meeting were reserved so that the ladies could shop or do sight-seeing on their own. Many, of course, visited Chinatown, rode the famous cable cars or visited the Missions, Golden Gate Park, or just enjoyed breath-taking views from famed hilltops.

In addition to their own events, wives joined their husbands at the Paul Bunyon Social Hour, official luncheon and the banquet.

The Moore FORCED AIR DRYER

SEASONS PINE AND HARDWOODS TO AIR-DRIED MOISTURE CONTENT



Moore Forced Air Dryer at Connor Lumber & Land Co., Wakefield, Michigan.

MOORE MODERN METHODS

Moore Modern Methods can now turn your inventory faster. The Moore Forced Air Dryer seasons considerably faster than yard drying—increases existing kiln capacities and produces brighter, flatter lumber with less stain. The Moore Forced Air Dryer offers further savings through low equipment and building costs. Designed for loads on rails or unit packages—5,000 board feet and up.

Write today for estimates on a Moore Forced Air Dryer to fit your needs.

MOORE DIVERSIFIED PRODUCTS MEAN MORE PROFIT FOR YOU!

- Dry Kilns (Track and Unit Package)
- Direct Heat Kilns
- Forced Air Dryers
- Cabinet Dryers
- Prefab Kiln Buildings
- Cross-Circulation Veneer Dryers
- Roller Veneer Dryers
- Steam Generators
- Recorder-Controller Instruments
- Fan and Heating Systems
- Dry Kiln Doors
- Dry Kiln Paints
- Moisture Meters
- Kiln Check-Up Service Plan
- Stackers (Kiln Load and Unit Package)
- Unstackers (Rake-Off, Tilting and Drop Out)
- Breakdown Hoists
- Loader Hoists
- Lumber Lifts (Cable and Hydraulic)
- Vertical Lifts (Cable and Chain)
- Transfer Cars (Power and Manual)
- Electric Swedes
- Turn Tables (Power and Manual)
- Lumber Conveyors (All Types)
- Sorting Chains
- Drop Sorters
- Dimension Sorters
- Tail-Boys (Cut Off Saw and Gang Rip Saw)
- Power and Gravity Rolls
- Special Engineering Services

MOORE SINCE 1879

MOORE DRY KILN COMPANY

JACKSONVILLE FLORIDA | BRAMPTON ONTARIO | VANCOUVER BRITISH COLUMBIA | NORTH PORTLAND OREGON

World's Largest Manufacturers of Drying and Handling Systems for Lumber and Veneer

28 Firms Exhibit at FPRS National Meeting

As has been customary on alternate years, the Society made available to the wood using industries and to their suppliers exihibit space adjacent to the technical session areas, in the form of booths and table tops. This year's exhibit attracted a total of 12 booth and 16 table top exhibitors, filling to capacity the available space. Individual reports from exihibtors indicated that they were highly pleased with the quality of lumber and wood products industries personnel represented, and that in a number of instances they had concluded sales of equipment, supplies, etc. Because the registration and service desks were located in the midst of the exhibits the more than 500 male registrants were in continual attendance throughout for four days that the exhibit was in progress.

A large measure of the success of the exhibit was due to the efforts of Chairman Victor S. Roth, Triangle Lumber Company, Oakland, California and his staff who were in attendance from morning until night, meeting every service need of the exhibitors. The Society is deeply indebted to these men for the smooth functioning and financial success of the exhibit.

General view of a corner of the exhibit area which was so successfully conducted during the San Francisco meeting.

Rowney Machinery Company
600–16th Street
Oakland 12, California

Mann–Russell Electronics
711 St. Helens Avenue
Tacoma 1, Washington
G. J. Russell

Suppliers' Booth and Table Top Exhibit

Orton Machine Company
390 Fremont Street
San Francisco 5, California
Knapp Orton, President

Mater Machine Works, Inc.
520 South First Street
Corvallis, Oregon
Jack C. Cooper, Sales Manager

Moisture Register Company
1510 West Chestnut Street
Alhambra, California
John R. Barnes, President

Soderhamn Machine Manufacturing Co
9442 Southwest Barbur Boulevard
Portland, Oregon

Kreiboum Export
Hannover, Germany
Dr. H. C. Mathuse, Manager

Kvalheim Machinery Company
P. O. Box 77
Petaluma, California
A. M. Kvalheim

For FAST, EFFICIENT DRYING *of*

VARIOUS WOOD PRODUCTS, VENEERS & FIBRE BOARDS

8 Line Gas Fired Coe Fibreboard Dryer

Wet end 10 section, 4 line, 12 ft. roll Model 48 Coe Veneer Dryer.

Industry Depends Principally Upon

COE DRYERS

Since the first Coe continuous dryer was built and sold in 1902 the design, construction and efficiency of these machines have been consistently improved.

Machines are now available in various types and sizes for drying fibreboard and veneer for many purposes including plywood.

Coe Dryers are conservatively rated and sold on a **guaranteed performance basis.** Almost without exception, performance has exceeded the guarantee.

Our engineering and research departments are always willing and anxious to cooperate in the development of drying processes for new wood products.

The COE MANUFACTURING CO.

PAINESVILLE, OHIO

28 Firms Exhibit at FPRS 13th National Meeting, San Francisco, June 1959

Stetson–Ross Machine Co., Inc.
3200 First Avenue, South
Seattle 4, Washington
C. W. Jones, Asst. Gen. Mgr.

Sel–Set Machinery Corporation
P. O. Box 1035
Salem, Oregon
G. N. Hybertsen, Sales Mgr.

Buttmer Works, Inc.
52 Vanderbilt Ave,
New York 17, N. Y.
Herman Baege, Vice President

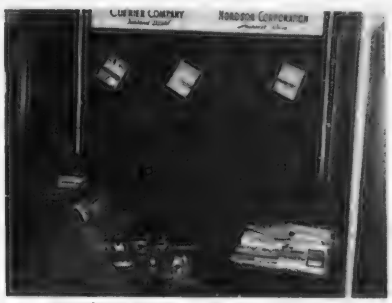
Bloxham Engineering, Inc.
2610 Ninth Street
Berkeley, California
John C. Bloxham, President

Binks Manufacturing Company
3114–40 West Carroll Avenue
Chicago 12, Illinois
George Knetl, Asst. Dir. of Engr.

Scott Lumber Company
Burney, California
Raymond H. Berry, Vice-President

McCulloch Corporation
6101 West Century Boulevard
Los Angeles 45, California
Raymond Linke, Sales Promotion Supvr.

Merit Products, Inc.
3691 Lenawee Avenue
Los Angeles 16, California
A. Block, General Manager



Nordson Corporation
Jackson Street
Amherst, Ohio

Roddicraft, Inc.
P. O. Box 248
Arcata, California
Robert K. Molloy
Manager, Timbland Division

Mill Equipment, Inc.
5219 First Avenue, South
Seattle 8, Washington
Lionel Pease, President

The Cardwell Machine Company
Franklin at 19th Street
Richmond, Virginia

Serving the Industry Since 1852

It's Revolutionary!
A-484M DIAGONAL PLANER and MATCHER

Upgrading of all stock, with astonishing improvement in finish on the lower grades now made possible with this revolutionary DIAGONAL PLANER and MATCHER.

DISTINCTIVE FEATURES

- ★ Elimination of sniped ends.
- ★ Smoother finish around knots and cross grain, with less tendency to loosen knots.
- ★ Continuous support of stock on bed plate before and after cut on bottom head.
- ★ Less lead required in guide as angle cutterhead serves to hold stock against the guide fence, preventing side friction, feed roll wear and edge sniping.
- ★ Less power consumption in feeding stock.
- ★ All operating adjustments can be made from the front or working side of machine.
- ★ Wide face helical gears for feed works, assuring continuous tooth mesh and quieter operation.
- ★ Independent quick green stock lift for first bottom feed-in rolls.
- ★ Bottom head cylinder can be pulled out for changing knives without disassembling motor.
- ★ Individual ball bearing housings for all cutting units.
- ★ All ball and roller bearings housed in dustproof housings. Grease lubricants for roll bearings. Regulated wick oil feeders used on all cutting units. Forced feed lubrication for feed gears.

Write Today for the A484-M Booklet

S. A. WOODS MACHINE CO.
27 DAMRELL STREET
BOSTON 27, MASS.

Masonite Corporation
111 West Washington Street
Chicago, Illinois
Don Silk, Sales Promotion Mgr.

Timesavers Sanders
Box 7446, Robbinsdale Station
Minneapolis 22, Minnesota
R. G. MacCune

Smithway Machine Company
4617 Airport Way
Seattle, Washington
Glen Grott, Sales Mgr.

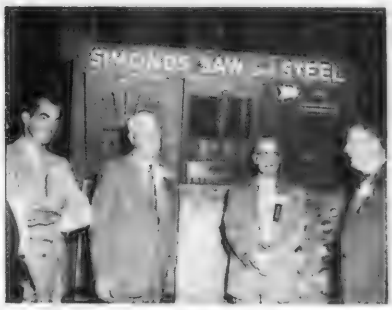
Crown–Zellerbach Corporation
343 Sansome Street
San Francisco, California

Miller Hofft, Inc.
P. O. Box 8718
Richmond 26, Virginia

Irvington Machine Works
1808 N. E. Seventh Avenue
Portland, Oregon
B. G. Leibel, Sales Mgr.

Yates–American Machine Company
Beloit, Wisconsin
A. W. Browne, Advertising Mgr.

Reichhold Chemicals, Inc.
P. O. Box 3547
Seattle, Washington
F. J. Shelton, Tech. Dir.



Simonds Saw & Steel Company
470 Main Street
Fitchburg, Massachusetts
E. J. Porter, Adv. Mgr.

Seventy Persons Active on San Francisco Arrangements Committees

Spaces does not permit naming all of the members of the 1959 National Meeting Committee. There were upwards of 70 persons who participated in the many functions of staging the successful national meeting. That this was one of the "workingest" committees in the Society's history is attested to by the fact that the steering committee alone met on 13 separate occasions between October 10, 1957 and June 17, 1959.

Such names as the Dickinsons, Berrys, Fields, Kuhns, Mansons, Roths, Sheltons, Van Beckums and others figure prominently in all of these activities. Perhaps the one person who worked the longest and hardest, outside of the General Chairman who worried the longest, was Miss Elizabeth Davenport who devoted the better part of a year of her activities as Secretary to this committee.

In the words of Ray Berry; "Like the Wandering Minstrel in 'The Mikado', our 1959 National Meeting has provided a program which we hope will meet your moods and tastes. 'Our catalog is long . . . and to your humor changing', from the wine testing exhibit by California Vintners at our opening get-together on Sunday night, through the many Technical Sessions and week-long activities".

The Society indeed owes a debt of gratitude to not only the members of the National Meeting Committee but also to the many authors of papers, and to the Division and Section officers who combined their talents at San Francisco.

F.P.R.S. Employment Committee Activity

In the absence of the permanent chairman, the Society was able to prevail upon Mr. R. W. Pettersen, St. Paul & Tacoma Lumber Company, a member of the national employment committee, to conduct the employment service at this meeting. An interview parlor was set up for four days (Monday, 1 to 3 P.M.; Tuesday, 10 to 12 A.M.; Wednesday, 1 to 3 P.M.; Thursday, 8 to 10 A.M.)

ONE POWASERT®

Nailing Machine Drives More Nails than 4 hammers

Even 20d nails fed and driven automatically without effort.

POWASERT closes boxes for fragile goods rapidly, accurately, and safely.

Single-blow POWASERT nailer, with speeds up to 250 nails per minute, and the POWASERT multiple-blow nailer and Feeder-separator supplied with both models.

Powasert Nailing Machines cut nailing time 60%. They reduce fatigue, speed production, eliminate nailing bottlenecks and do a better job. Increased safety: no bruised fingers; bent or flying nails are eliminated. Morale is improved. Money is saved.

A window manufacturer in Minnesota reports a 50% reduction in the total time required to manufacture their windows. Powasert nailers also permitted conveyorizing the production line. Hammer marks were eliminated.

An Illinois woodworking company reported they were producing 8 top and bottom crate sections each hour. After a Powasert nailer was installed production leaped to 32 top and bottom crate sections each hour for a 400% increase.

A boat builder uses nails for high quality sea skiffs — replacing screws — and increased production of decks, floors, and small parts by 60% and over-all production by 15%. Production has increased from 8 to 15 boats a week.

If you are nailing by hand in any volume, Powasert Nailers can help you cut costs and improve quality. Write us today for more information or a trial in your plant on your production line.

United

UNITED SHOE MACHINERY CORPORATION
140 Federal Street, Boston, Massachusetts

Minutes of Thirteenth Annual Business Meeting

THE THRTEENTH ANNUAL business meeting of the Forest Products Research Society was called to order by President W. Jeter Eason at 11:30 A.M., Monday, June 29 in the Italian Room of the St. Francis Hotel. Approximately 75 to 100 members were in attendance.

1. **Minutes of the 1958 business meeting**

The preceding annual business meeting was held in Madison, Wisconsin, June 24, 1958. The minutes of that meeting were published in the October, 1958 *Forest Products Journal*. It was moved and seconded that these minutes be approved. Motion carried.

2. **Annual report of the Executive Secretary**

Frank J. Rovsek, Executive Secretary, Madison, Wisconsin, reported that the Society's membership and subscriptions totalled 3,603 as of January 1, 1959 compared to 3,653 January 1, 1958. The increment of loss was 1.4% compared to gains of 5.7% in 1957 and 14.7% in 1956. The Society now has members in over 40 countries throughout the world.

Financially, the Society began the year 1958 with cash on hand of $11,700 and concluded the year's operations with cash on hand of $4,125. Its fixed assets in the form of its new executive office building and furniture and equipment inventory was conservatively valued, after depreciation, at $62,128. Total liabilities, principally in the form of prepaid membership dues for 1959, amounted to $7,324. Thus, the Society increased its net worth from $26,620 at the end of 1957 to $54,804 at the end of 1958.

3. **Report of the Budget and Finance Committee**

In the absence of the regular chairman, W. L. Irwin, Poinsett, South Carolina, President Eason reported that the Society's accountants, Mr. V. C. Hobart and I. H. Guthneck met with the Executive Board during its meeting in Madison in January and reported that the summary of the financial condition. (Operating statement and balance sheet published in the April issue of the *Forest Products Journal*.

4. **Report of the Constitution and By-Laws Committee**

Chairman Don Saunders reported that virtually all of the Society's 13 Sections have either approved or enacted by-laws in conformity with the model by-laws recommended by the National. He also advised of great progress in the direction of establishing the legal status of the Subject Matter Divisions in the Society's constitution and by-laws. At this meeting copies of an advance draft form of amendments generally patterned after provisions for Sections will be discussed with the Division leadership.

5. **Report of the Division's Coordinator**

Raymond Berry, Division Coordinator, reported on the progress of the Society's 14 Divisions which coincidentally equal the number of Sections in the Society. The Divisions have all come into being since 1950 and the last of these was organized in 1956. Mr. Berry stressed the deadlines for divisional work so vital to the publishing and meeting program of the Society; September 1 for business meeting minutes for October Yearbook issue; December 15 to submit "Annual Reviews" for February 1960 *Journal;* February 15, 1960 for the final program development for the Montreal National Meeting. The important thing he said is to draw together the Sections and the work of the Divisions. This could be done theoretically by having each of the 14 Divisions represented by an ex officio member on the boards of direction of the 14 Sections.

6. **Report of the Thirteenth National Meeting Committee**

Raymond Berry, General Chairman, reported that as of this business meeting there were accounted for well over 600 registrations, including 176 ladies. The goal, he said, was 700 registrants. He thanked the Paul Bunyan donors who had contributed several thousands of dollars to offset the social hour to be held at the Olympic Lakeside Club and the entertainment for the banquet. He emphasized the high cost of holding a convention in San Francisco where the Society was required to absorb as much as $600 per day for rental of meeting room facilities alone.

7. **Report of National Membership Committee**

Tony Veazey, Chairman, reported on the current drive to reach 4,000 paid up members during the calendar year 1959. As of June 18 we reached an all-time high of 3,905 members, an increase of 224 in one year. He described the "grass roots" membership efforts of the Society's Sections now in progress. In April he made a trip meeting FPRS officers in Minneapolis, Madison, Grand Rapids, Buffalo, Charlotte, New Orleans, Los Angeles and San Francisco. The conclusion drawn from numerous conversations was that membership must be promoted locally rather than nationally and preferably on a person to person basis.

Mr. Veazey then presented the Society's annual felt banner awards to the Sections which had shown the greatest increment of new members in the previous year. First award went to the Mid-South Section and was accepted by Membership Chairman Harry Russell. The second award went to the Pacific Northwest Section and was accepted by Earl McCarthy. The third award was presented to the Pacific Southwest Section.

Publications Committee Recommends Added Funds For Expanded Journal

An expanded *Forest Products Journal,* garbed in a new cover, with more and longer articles were goals set up by the Publications Committee at its annual meeting in San Francisco last June.

The Committee stated that the Society should spend more on the Journal, that the resulting improvements would increase membership and benefit the Society as a whole.

New Cover

A brighter, fresher, more dynamic cover was one suggestion considered. The group agreed that the present green of the *Journal* should be replaced by a color more closely resembling wood. From several sample covers prepared by a commercial artist, the Committee tentatively selected cover No. 2, a white cover with a distinctively colored box containing FPRS's research emblem.

It was also suggested that each article be footnoted to show the date it was submitted to the *Journal.*

It was strongly recommended that the *Journal* publish technical articles longer than the six or seven pages that is now the average, and that the Society continue to encourage the use of graduate theses.

More Funds Needed

Two ways of providing more funds for the *Journal* were discussed. One, it was suggested a fund be earmarked

National Membership Committee meets to discuss long range membership objectives.

Members of national Publications Committee meet to discuss long range publications objectives.

for the *Journal* and companies and individuals be urged to contribute to that fund.

The second suggestion was to increase membership dues. The Committee agreed unanimously that there would be little or no objection to dues of $18 to $20, providing the increase resulted in an expanded *Journal*.

The possibility of two publications was also discussed—a quarterly technical journal and a monthly general publication. After lengthy discussion, it was moved and seconded that the Committee recommend to the Executive Board that the *Journal* remain the sole publication of the Society. The motion was carried.

Publication Policy

The Committee also called for a published statement of publication policy to be published in the *Journal* and kept available in reprint form for new authors. Committee members agreed to submit additional ideas on this to the Chairman.

Editor's Report

Editor R. H. Hamre reported that the backlog of papers was about the same as last year. In the past year, 143 articles were published, 131 papers were on hand, and 124 papers were being reviewed. During the year, the Journal averaged 9 to 12 articles per issue, 25 articles in the October yearbook, and 10 articles in the February Review issue.

Editor Hamre announced his resignation to accept a position at the U. S. Forest Products Laboratory. This was noted with regret and the editor was commended for a highly successful year.

Report of Tellers Committee

Chairmen of the Committee, Lester J. Carr, reported that the Tellers Committee met on Sunday, June 28 and counted 788 official ballots, representing approximately 25% of the eligible voting membership. He reported that the following persons were elected to office: President-Elect, Raymond H. Berry; Vice President, W. L. Irwin; South Central Regional Board Member, James L. Love; Southeastern Regional Board Member, Walton R. Smith. Mr. Carr then read a letter of resignation received from Mr. Irwin who indicated that because of a change in his Company's policies he regretted that he must decline the honor. In subsequent action the Executive Board elevated Donald K. Saunders of Westbrook, Maine to the post of vice-president, and appointed Col. John H. Jenkins, Ottawa, Canada to a one-year term as Northeast Regional Board Member.

Elected to the National Nominating Committee were: Herbert O. Fleischer, O. Harry Schrader, Jr., John B. Grantham and G. Maurice Hill.

Report of Resolutions Committee

The report of the resolutions committee was read by Moss B. Christian, Chairman.

1) The Society records with deep regret the passing during the past year of the following members: Wm. B. Mitchell, Ralph K. Day, Russell G. Knutson, E. E. Matson, Henry During, W. T. Harrison, L. G. Cox, Thomas J. Mitchell, Robert C. Seavers, Jr. and C. H. Robinson.

Be it resolved that this expression of sympathy to the families and friends of these members be included in the permanent records of this meeting and of the Society.

2) In appreciation of the meritorious services that have been rendered to the FPRS during their term of office, be it resolved that the gratitude of the Society be extended to each of our outgoing officers, including Executive Board Members, Section and Division Officers and Committee persons.

3) Recognizing that the success of this 13th Annual Meeting is in a large measure due to the foresight, planning and diligence of the Annual Meeting Committees, be it resolved that the Society hereby acknowledge its appreciation to the members of our Northern California Section and others for their excellent and successful work.

Tellers' Committee, all happily smiling, despite tabulating results of 788 official ballots.

4) In view of the splendid cooperation and the services provided by our host hotel, the St. Francis, our 87 Paul Bunyan Hour Sponsors, and our 28 Exhibitors,

Be it resolved that the appreciation of the Society be extended to the management and staffs of these organizations.

Finally, be it resolved that the gratitude of the society be extended to each and every author and Committee worker who has worked so diligently to achieve the success of this meeting.

New Business

Milton Mater, Chairman of the Sawmilling Division, recommended the establishment of a special committee of the Society whose function it would be to explore long range research needs of the forest products industry. He noted that industry is progressing in the direction of hiring more technically trained men. He felt that the Society should have a committee to view the long range research needs of the industry at large and thus give it impetus and direction. He stressed that it should be a function of the Society to investigate the research climate and health of this industry.

The meeting was adjourned at 12 noon.

Sections Plan "Grass Roots" Recruiting Campaign

NLMA–FPRS Program to Be Tailored for Each Locality to Encourage Promising Young Men to Enter Careers in the Wood Industry

A DEDICATED EFFORT to attract promising young men to careers in all phases of the wood industry—technology, sales, production, and skilled trades—will be put forth by the FPRS Sections to speed progress on the NLMA–FPRS Industry Education Program.

Plans were laid at the Tenth Annual Meeting of the Section Officers Advisory Committee and the National Executive Board. The meeting was held at the St. Francis Hotel, San Francisco, July 1, 1959.

NLMA–FPRS Booklet

"Mere publication of literature, such as the cooperative NLMA–FPRS booklet on "Careers in the Wood Industry" is not enough to attract the bright young minds we want and need in the wood industry. To be successful, the booklet must be supplemented with a "grass roots recruitment campaign" tailored to fit each wood industry locality in the United States, "reported Ray Berry.

Local Campaigns

To further this end, each of the 14 Sections will develop localized campaigns fitted to localized wood industry patterns. Eight Sections have already established sub-committees to conduct this work.

The plans call for the Sections to set up local programs and to include such varied activities as plant tours, exhibits, and lectures at universities, high schools, and elsewhere.

The campaign will be under the general guidance of Dr. John Zerbe, NLMA staff member who has been a key man in the cooperative efforts of NLMA and FPRS on this subject.

Other Business

Other important business conducted at the meeting included a recommendation that a new class of membership be added to the Society. It was suggested this class might encourage smaller companies to become sustaining members for $50 when they might hesitate to join as supporting members for $100.

Considerable discussion was aso held on the subject of preprints of papers presented at technical sessions. It was agreed that the Executive Board will take this question under advisement.

Other business conducted is reported in the minutes of the meeting, which follow.

Traditional Executive Board-Section Officers Advisory Committee luncheon.

SECTION OFFICERS—EXECUTIVE BOARD ADVISORY COMMITTEE MEETING

1) President W. Jeter Eason called the meeting to order at 1:00 P.M.

2) Mr. Eason then turned the meeting over to incoming President, E. S. Harrar, who remarked that he planned to visit each of the Society's 14 Sections during the fall or winter of 1959. He urged that in large geographic areas the adjacent Sections might schedule meeting dates coincidentally so that he could plan to make a swing of two or three Sections within a period of a week.

3) Dr. Harrar called upon the chairman of the Section Officers' Advisory Committee, Charlies Kreider, to review the recommendations of the Sections. Mr Kreider noted that all Sectinos were represented at this meeting except for the Ohio Valley, Pacific Southwest, and Rocky Mountain Sections.

The recommendations were as follows:

4) The Section officers recommend that preprints be made available in conjunction with our national meetings.

Dr. Kaufert noted that availability of preprints, if mailed before the national meeting, might detract from attendance. Phil Northcott stated that by having preprints a member can be able to select which technical sessions he wishes to attend. He can listen and absorb the information instead of taking inadequate notes. Fred Dickinson indicated the problem that one cannot sit in on two or three sessions simultaneously in which he is interested; and the larger problems that one must wait as long as 12 months following a national meeting before he may see publication of a particular paper of that meeting. Eric Anderson noted that the Northeast Section has for years followed a policy of issuing preprints in connection with their section meetings. Ray Berry noted the problem of expenses of producing preprints and the problem of getting them out. In the same vein Phil Northcott noted that ASME requires complete papers from authors four months in advance of their scheduled presentation.

5) The Section officers recommended that the Executive Secretary send a questionnaire form to each Section each month in order to obtain Section news information for the News Digest portion of the Journal in an effort to stimulate interest in Section meetings and interest.

The Executive Board instructed the Secretary to so proceed.

6) The Section officers recommended that each Section have represented on its standing committees one man from each of the Society's 14 Divisions in order to assist with Section program activities.

7) The Section officers recommended the creation of a new membership class within the Society of $50.00 company members.

8) Following the advisory portion of the meeting, Ray Berry reported on the progress of the NLMA–FPRS Industry–Education Program to date.

The meeting was adjourned at 1:45 P.M.

ATTENDANCE

A list of the sections represented and the members attending follows: Northeast—E. A. Anderson, D. K. Saunders; Eastern Canadian—R. F. DeGrace; Carolinas–Chesapeake—E. S. Harrar, W. R. Smith, J. S. Bethel, George Smith, J. I. Zerbe; Southeastern—R. H. Page, D. M. Post; Midwest—J. J. Allegretti, Jack Koellisch, F. J. Rovsek (National Office); Great Lakes—S. B. Preston, Hereford Garland; Ohio Valley—None; Upper Mississippi Valley—F. H. Kaufert, B. M. Granum, P. H. Lane; Mid-South—J. L. Love, W. R. Warner, M. M. Lehrbas, W. C. Hopkins, W. J. Eason; Inland Empire—Irv Wentworth, John Howe, Tony Veazey, C. Kreider; Pacific Northeast—R. W. Wellwood, W. I. West, P. L. Northcott; Pacific Southwest—None; Northern California—R. M. Kuhn, F. E. Dickinson, Leyden Ericksen, R. H. Berry; V. S. Roth; Rocky Mountain—None.

Continuous Pulping

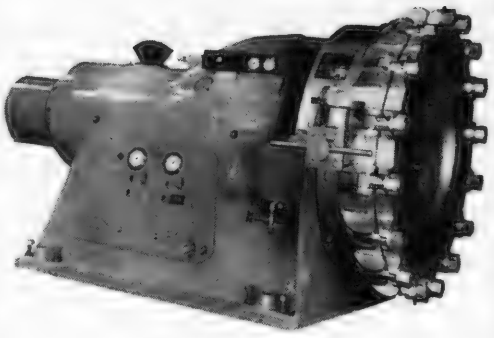
CONTINUOUS DIGESTER

American Defibrator, Inc., offers equipment to meet various demands for continuous pulping of cellulose raw materials. Complete units or components are available for economical production of controlled grades of pulp for the Paper, Wallboard and Roofing Felt Industries.

American Defibrator Continuous Digesters with Screw Feeders or Rotary Feeders and Asplund Defibrators produce pulp at substantial savings in production cost. The capacity of the Defibrator Continuous Digesters ranges from 50 to 250 tons of pulp per day or more. Various raw materials may be used, such as softwood, hardwood, cotton linters or bagasse.

Non-chemical high yield pulps produced by the Asplund Defibrator are used for the manufacture of hardboard, insulating board and roofing felt. Semi-chemical pulps for corrugating medium as well as bleachable grades and pulp for newsprint furnish are also produced by the Defibrator Continuous Digester.

The large size Type D-42 Defibrator is now available and has been developed to meet the current trend in the Pulp and Paper Industry towards larger production units. This Defibrator is driven by an electric motor directly connected to the main shaft by a gear coupling. The grinding pressure is hydraulically controlled and easily adjusted. Therefore uniform, high quality pulp is produced and D-42 units now in operation indicate capacity of about 100 tons/day of non-chemical and 200 or more tons/day of semi-chemical pulp.



TYPE D-42 Defibrator

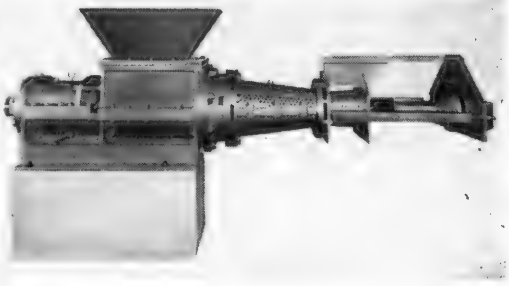
ASPHALT DISPERSION PROCESS

The Asplund Defibrator for treatment of waste paper stock in the "A-D" system has found an extensive application in the Paper Board Industry in order to disperse asphalt, waxes and similar materials in the waste paper. As a result, a clean and sterile sheet is made on the paper machine at considerable savings, since less expensive waste paper can be utilized. Processing costs for steam, power, labor and maintenance are low. No chemicals are required. Total annual capacity installed now exceeds 1½ million tons of waste paper. Inquiries receive prompt attention.

Continuous Dewatering

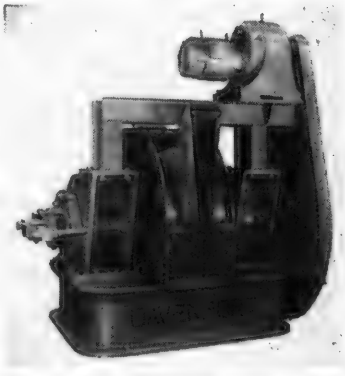
THE DEFIBRATOR BARK PRESS

The Defibrator Bark Press was developed for continuous dewatering of bark for use as fuel. Processing capacity is about 4 to 5 tons per hour, bone-dry basis. The power consumption at this rate runs between 60 and 75 H.P. The continuous operation reduces labor and maintenance costs to a minimum.



THE DAVENPORT DEWATERING PRESS

The Davenport Continuous Press extracts water from fibrous materials, such as various grades of waste paper stock, kraft, sulphite or groundwood pulp. The Model 1B Press has a capacity of about 75 tons/24 hours of pulp, bone-dry basis, dewatering the stock from about 10% consistency to about 35% consistency or higher. The wet pulp entering the press is squeezed and dewatered as it passes through the press and the squeezed out water escapes through the screen plates and drains off at the bottom of the press. There are practically no fiber losses. The pulp is handled very gently by the press which operates at low speed. Therefore, no "fish eyes" are formed in the pulp during the dewatering. The Davenport Press operates very efficiently with low power consumption, high capacity and low maintenance cost. Inquiries receive prompt attention.



AMERICAN DEFIBRATOR, INC.

CHRYSLER BUILDING
NEW YORK 17, N. Y.

West Coast: A. H. Lundberg
Mercer Island, Washington

Divisions Seek Legal Status through National Bylaws

Outgoing Division Coordinator Raymond Berry discusses division growth as Chairman Don Lubeck and newly elected coordinator Don Saunders, right, look on.

Traditional Executive Board-Division Officers' Advisory Committee luncheon.

Executive Board to Consider Recommendations Made at Advisory Committee Meeting to Institute Constitution Changes

EFFORTS OF THE DIVISION OFFICER'S Advisory Committee and member of the National Executive Board are bringing the Subject Matter Divisions closer to full legal status in the Society.

These efforts should eventually culminate in the Divisions, now largely considered the vertical strata of FPRS, being on par organizationally with the Sections, which are considered the horizontal subdivisions. Both groups will be strengthened as a result of contemplated measures.

Third Annual Meeting

Progress on these efforts was reported at the third annual meeting of the members of the Executive Board and the Division Officers' Advisory Committee, which was held during the 13th National Meeting in San Francisco, July 2, 1959.

At a closed officers session held June 29, the Advisory Committee proposed recommendations that the Executive Board draw up a constitutional amendment to establish the legal entity of the Divisions within the framework of the Society.

Bylaws

It was also agreed that the amendment should include provisions for bylaws and procedures under which the Divisions could operate, and that it should establish as a minimum requirement of officers the posts of : chairman, vice-chairman, and secretary.

The Board is currently studying recommendations it plans to report back to the Divisions following its November meeting.

Other Business

The Committee also voted to recommend to the National Program chairman that each paper presented at the National Meeting be assigned a number and a time for presentation and that no change in order or time be permitted. It was also suggested that the number of the paper be posted outside the meeting room when that particular paper is being presented.

This, would permit members to move from one technical session to another to hear the papers of greatest interest to them.

These recommendations will also be placed on the agenda for the next Executive Board Meeting on procedures.

The following Board and Division members attended the meeting:

E. S. Harrar, J. J. Allegretti, Masonite Corporation; Paul Heller, Lumber Manufacturing; Milton Mater, Lumber Manufacturing; Fred Simmons, Logging; Edward G. Locke, Chemical Utilization; A. L. Mottet, Wood Comp. Board; A. R. Tegge, Packaging Division; E. L. Ellwood, Wood Drying; Walton R. Smith, Board Member; John Lutz, Veneer & Plywood; William B. Lloyd, Merchandising; Richard F. Blomquist, Glues & Gluing; Robert J. Hoyle, Wood Machining; Aubrey E. Wylie, Quality Control; John McMillen, Wood Drying; J. S. Bethel, Industry–Education; Tony Veazey, Lumber Manufacturing; James L. Love, Board Member; R. W. Pettersen, Employment; W. J. Eason, Board Member; Don Saunders, Board Member; Ray Berry, Board Member; Don Lubeck, Wood Finishing;

Chemical Utilization Division's Annual Review Is Best Seller —No. 1 Reprint Requested of Institute of Paper Chemistry

A. S. Gregory, Chairman, Weyerhaeuser Timber Co., Longview, Wash.

The meeting was called to order July 1, 1959 at 1:30 p.m. in San Francisco. Vice-chairman Pearl acted in Chairman Gregory's absence.

I. Program Committee

Dr. E. G. Locke, chairman, reported that the Monday session was well attended, but attendance at the Thursday session was dubious. Considerable discussion underlined the undesirability of having split meeting days, and it was urged that the Division Chairman request consecutive sessions for next year's meeting at Montreal. Dr. Locke had encountered the usual difficulty in obtaining authors of papers, but he developed sufficient leads to be hopeful for two sessions in Montreal.

II. Secretary's Report

The report was read and approved with no changes.

III. Annual Review Committee

Dr. Pearl, reporting for Dr. Gregory, stated that the Division's Annual Review of Chemical Utilization, which was edited by The Institute of Paper Chemistry and included the new section on literature review on extractives, was No. 1 of reprints requested from the Institute of Paper Chemistry. Discussion of the Annual Review revealed strong support for (1) a complete review by the Division as in the past, (2) the publication of references in the review article, and (3) subdividing the review into separate sections in spite of the subject classification prob-

lem. The sentiment was expressed that the past review articles have been extremely well done.

IV. Memorial Lecture Committee

Chairman F. G. Perry, Jr. reported that the committee agreed the Society as a whole should sponsor a memorial lecture, because separate efforts by Divisions would be ineffective and impractical. The following resolution was adopted:

"The Chemical Utilization Division hereby informs the Executive Board of its desire to actively support the concept of establishing an FPRS Memorial Lecture. It is agreed that: (1) the lecture be given a prominent role at the Annual Meeting; (2) the lecturer be a prominent man in his field capable of delivering a lecture of broad technical interest to the membership; and (3) an honorarium be raised by suitable sponsorship, and the various Division's recommendations be sought as to suitable lecturers."

Irwin Pearl served as chairman of the Chemical Utilization Division board meeting, assisted by T. G. Perry, Jr.

Further discussion under this committee's report dealt with the question of the Division's sponsoring a student award. The concensus was that we should strive for chemical utilization recognition through the existing medium of the annual student "Wood Award." Fred Dickinson pointed out that the Society mails notices concerning the Wood Award to various colleges, and made the suggestion that our Division Chairman follow up to be sure that colleges with chemistry, biochemistry and other pertinent curricula be included in the invitation to compete for the Wood Awards.

V. News Release Committee

No report as the chairman, Dr. J. Saemen, was not present.

VI. Chemical Utilization Directory Committee

Dr. I. A. Pearl, Chairman, reported that some companies have been cooperative, and some have been reluctant to disclose their interests in by-products. The committee is hesitant to publish a formal list that, at best, is only a partial list of companies active in the field. It was suggested that the committee informally send this partial list to Division members, requesting appropriate additions.

VII. Bibliography Committee

Reavis C. Sproull, Chairman, reported this committee is a carry-over from several years ago. Dr. Sproull stated that the purpose of this committee was now being fulfilled by the Annual Review, and he moved that the committee be disbanded. The motion carried unanimously.

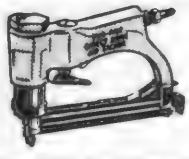
VIII. Nominating Committee

R. C. Sproull, Chairman, reported that the following were nominated for the 1959–1960 term of office: Chairman, Dr. Irwin A. Pearl; Vice-Chairman, Mr. Fred G. Perry, Jr.; Secretary, Dr. Jerome Saeman.

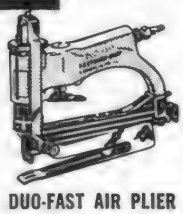
There being no further nominations from the floor, the above officers were duly elected.

The following committee chairman were appointed: Program Chairman for Montreal Meeting, F. G. Perry, Jr.;

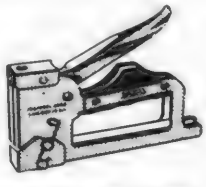
DUO-FAST Tackers and Staplers for the WOODWORKING INDUSTRY



DUO-FAST AIR TACKERS
Fast, effortless, efficient tackers for production work. 20 various models.

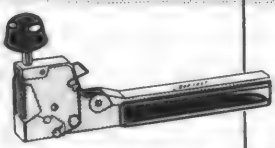


DUO-FAST AIR PLIER
Light, easily portable air-driven staplers. 8 various models.

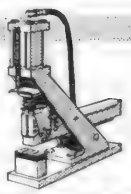


DUO-FAST GUN TACKERS
Great all-purpose hand tackers. 18 various models.

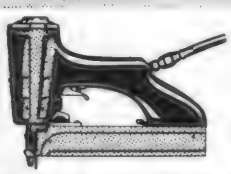
DUO-FAST HAMMER TACKERS
Fastest, manual tacking method. 6 various models.



DUO-FAST STRIKE TACKERS
Two-hand tackers for accurate placement of staples. 15 various models.



DUO-FAST BENCH MODELS
Air-operated staplers or tackers designed for bench-mounting. In single or multiple units. 11 various models.



NEW! DUO-FAST BRAD GUN
Sensational new tool drives brads 1" and 1¼" long, into the hardest materials, at 40 to 80 pounds air pressure. Remarkably light, easily-handled, and recoil-free. You just flick the trigger; air does the rest.

At Your Service . . .
Duo-Fast offers a complete line of Staplers, Tackers, and Staples–a Free Service Guarantee –and 50 sales and service offices to help you with your fastening problems.
Write for complete Duo-Fast Story.
DUO-FAST FASTENER CORPORATION
3700 River Road FRANKLIN PARK, ILLINOIS

Annual Review Chairman, I. A. Pearl, with John W. Rowe of Forest Products Laboratory to be co-author.

IX. Bylaws

Dr. Pearl reported that the Society was revising its bylaws to take into account the present Divisional structure, and to effect other needed changes.

Dr. Sproull commented on the general lack of industrial support of the Division's activities, and a plea was made for obtaining more widespread individual interest. Only through individuals can the needed support be obtained.

The meeting was adjourned at 3:30 p.m.

The following were present:

F. H. Snyder, Francis H. Snyder & Associates, Inc., 29 Church Street, New Milford, Conn.; R. C. Sproull, Consultant, 212 Ross Road, Richmond, Va.; Winton Patrode, 30 Country Club Drive, Tacoma, Wash.; D. L. Kenaga, The Dow Chemical Company, Midland, Michigan; F. W. Herrick, Rayonier Incorporated, Shelton, Washington; I. A. Pearl, Institute of Paper Chemistry, Appleton, Wis.; E. G. Locke, Director, Forest Products Laboratory, Madison 5, Wis.; F. G. Perry, Jr., Arthur D. Little, Inc., 15 Acorn Park, Cambridge 40, Mass.; F. E. Dickinson, University of California, Richmond, Calif.; G. K. Lissner, Chemical Process Company, Redwood City, Calif.; Jean Mater, Mater Engineering, P. O. Box 236, Corvallis, Oreg.

Wood Gluing Division Considering Book on Wood Gluing, Interpretative Work on Standards, a Bibliography

R. F. Blomquist, Chairman, U.S. Forest Products Laboratory, Madison, Wis.

I. Bylaws

The present procedure for determining officers, their tenure, elections, official duites, etc. are now rather informal. The problem was discussed, and plans were made to have uniform procedures by the next annual meeting.

II. Division Representatives in Sections

Chairman Blomquist suggested the desirability of dividing the membership into separate groups for each of the 14 sections and appointing one committeeman to be in charge of all gluing work in each section.

The suggestion was put forth as a motion by Ed Cook and seconded by Joe Marian. The motion was passed.

III. Technical Sessions for 1960

Plans were put forward that the Division have two technical sessions at the National Meeting in Montreal. The motion was made by Phil Northcott and seconded by Jake Ash. The motion was carried.

Other discussion included suggestions that additional papers on elastomer (including structural problems) be included; that two or three papers be followed by a panel discussion; or that two papers per session be followed by discussion.

It was finally moved and seconded that the Division hold one session on theoretical or fundamental work and the other on the applied or practical side. The motion was carried with some dissention.

IV. ASTM on Wood Adhesives

J. R. Ash, Monsanto Chemical Co., reported on the West Coast subcommittee's activities on the ASTM standard on wood adhesives.

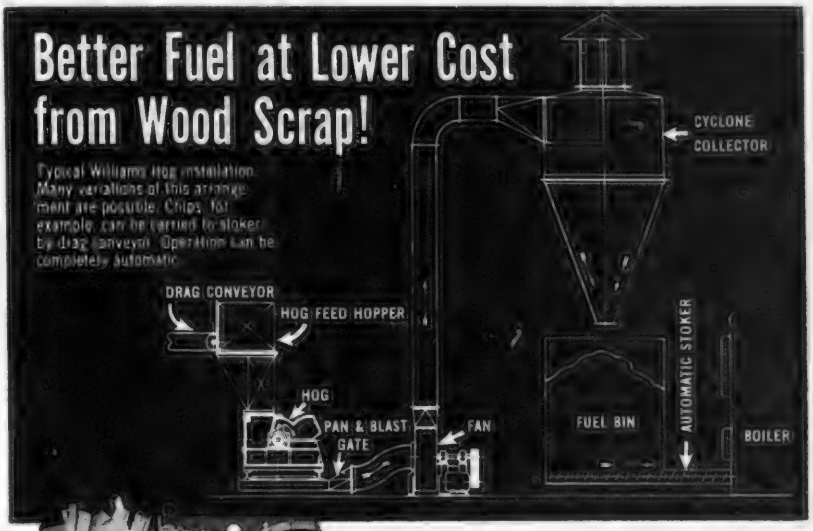
V. Future Projects

General discussion indicated that the following topics might be considered as possible special projects for the Division:

1. Preparation of a comprehensive book on the gluing of wood.
2. The compilation of good papers on the subject of gluing.
3. Interpretative work on Standards
4. The compilation of a thorough bibliograp[1].

The following attended the meeting:

R. F. Bloomquist, U. S. Forest Products Lab., Madison, Wis.; A. H. Rauch, U. S. Plywood Corporation, Seattle, Wash; H. M. Preusser, American–Marietta Co., Seattle, Wash.; J. D. Fair, U. S. Plywood Corporation, Anderson, Calif.; Joe Marian, Univ. of California, Berkeley, Calif.; Donald Stumbo, Univ. of California, Albany, Calif.; Ed Cook, Simpson Redwood–Arcata, Calif., Eureka, Calif.; Gordon Borchgrevink, Weyerhaeuser Timber Co.—CR&D, Long-


Better Fuel at Lower Cost from Wood Scrap!
Typical Williams Hog installation. Many variations of this arrangement are possible. Chips, for example, can be carried to stoker by drag conveyor. Operation can be completely automatic.
CYCLONE COLLECTOR
DRAG CONVEYOR
HOG FEED HOPPER
HOG
PAN & BLAST GATE
FAN
FUEL BIN
AUTOMATIC STOKER
BOILER

Cross section of "No-Nife" Hog shows how chisel-edge hammers reduce wood by impact until properly sized to pass through grates in bottom of hog.

A COMPLETE LINE:
- Hogs, Grinders & Shredders
- Air & Mechanical Separators
- Vibrating Screens
- Cyclone Collectors
- Heavy Duty Fans

WILLIAMS "No-Nife" HOGS

Wood scrap reduced to chips in a "No-Nife" Hog is almost 100% combustible—cheapest of fuels for heat and power. Unhogged, wood won't burn evenly, restricts air flow, smothers fire, causes excessive smoke and soot.

Hogging also cuts handling cost up to 75%. One man can handle as much tonnage in chips as three men handling long, awkward, odd-shaped pieces. Labor savings alone pay for most "No-Nife" Hog installations in a few months. *Write for brochure today.*

WILLIAMS PATENT CRUSHER & PULVERIZER CO. 2714 North 9th Street St. Louis 6, Mo.

WILLIAMS
CRUSHERS GRINDERS SHREDDERS
OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

view, Wash., T. A. Getsiv, Weyerhaeuser Timber Co., Longview, Wash., R. L. McNett, Biles–Coleman Lbr. Co., Inc., Omak, Wash.; R. A. Waldron, Weyerhaeuser Timber Co., Longview, Wash.; A. J. Long, Monsanto Chemical Co., Santa Clara, Calif.; R. A. Currier, Forest Products & Research Center, Corvallis, Ore.; J. R. Ash, Monsanto Chemical Co., Seattle, Wash.; J. M. Hine, The Borden Chemical Co., Seattle, Wash.; Donald Percival, Small Homes Council, Universitv of Illinois, Champaign, Ill.; John Lutz, U. S. Forest Products Lab., Madison, Wis.; J. A. Clarke, Dow Chemical Company, Freeport, Texas; Frederick L. Brown, Dow Chemical Company, Midland, Mich.; William Martin, Productol Company, Santa Fe Springs, Calif.; Ralph Casselman, Simpson Logging Co., Portland Ore.; F. W. Herrick, Rayoneir, Inc., Shelton, Wash.; Everett Reichman, Simpson Logging Co., Shelton, Wash.; R. H. Ripley, Douglas Fir Plywood Association, Tacoma, Wash.; P. L. Northcott, FPL of Canada, Vancouver, B. C.; M. M. Stover, Borden Chemical Co., Seattle, Wash.; W. H Miles, Bremerton Naval Shipyard, Bremerton, Wash.; W. R. Francis, Simpson Logging Co., Shelton, Wash.; William A. Whelan, U. S. Plywood Corporation, Eugene, Ore.; N. S. Perkins, Douglas Fir Plywood Association, Tacoma, Wash.; R. W. Wellwood, University of B. C., Vancouver 8, B.C.; and Henry Sandstrom, Diamond Gardner Corporation, Chico, Calif.;

Wood Finishing Division Hears ASTM Report on Hot- and Cold-Print Tests for Lacquers

D. G. Lubeck, Chairman, Hammond Organ Co., Chicago, Ill.

I. New Vice-Chairman

The meeting was opened by Chairman Lubeck at 3:30 P.M. He announced the resignation of Vice-chairman Donald Laughnan and stated that he would contact the steering committee (sub-committee chairmen) for suitable names for a successor. He said that the Divisions were soon to become part of the Society and then bylaws could be established for electing officers in a regular manner.

II. Plans for National Meeting

The following suggestions were made for the National Meeting in Montreal next year:

(1) The Chairman of the Montreal Meeting is to be contacted to obtain the theme of meeting and possible suggestions for those to give papers.

(2) E. W. Wellwood stated that we seemed to be heavy on Eastern subjects and suppliers at this meeting and suggested that we recognize other phases of wood finishing and the West Coast at the Montreal Meeting.

(3) It was suggested that Max Yan of Abitibi Power and Paper Co., Sault Ste. Marie, Ontario could offer suggestions for the meeting.

(4) F. H. Thomas suggested that men from the Sherwin Williams Laboratories at Montreal could be called upon for papers.

III. Midwest Section Meeting

Chairman Lubeck announced a Midwest Section meeting to be held in conjunction with the North Central Regional Meeting in Chicago November 5–6. The theme of the entire meeting is "Better Factory Finishing of Wood Products." Donald G. Lubeck will be program chairman of this meeting.

IV. Sub-committee XXV, ASTM-D1

R. F. Buller, Chairman, reported that the sub-committee has the following subjects under study: (1) Hot and cold print test for lacquers; (2) Accelerated test for settling of flatting agents.

V. General

E. W. Wellwood recommended that the Division endorse preprints so that papers can be condensed and more time given to discussion.

R. R. Teasdale suggested only digests of papers be given at technical sessions, thus allowing more time for discussion periods.

Chairman Lubeck reminded the members of the need for collecting reports on finishing developments in 1959 for use in the February 1960 issue of the Forest Products Journal.

The meeting was adjourned at 5:00 p.m.

The following attended the meeting:

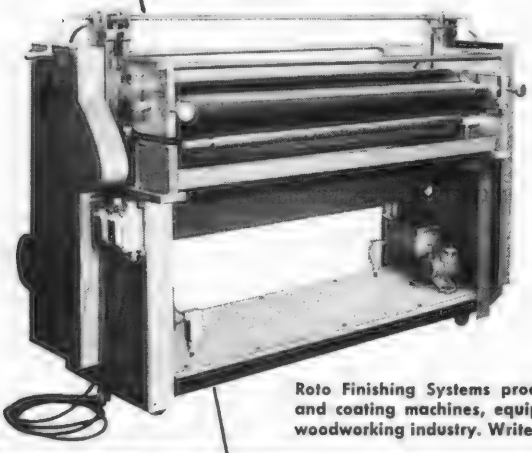
R. F. Buller, Shell Chemical Corp., 1120 Commerce Ave., Union, N. J.; D. J. Olmetti, V. J. Dolan Co. Inc., Chicago, Ill.; W. A. Gullicksen, Churchill Cabinet Co., Chicago, Ill.; E. W. Wellwood, Canadian Forest Prod., North Vancouver, B. C., Canada; G. Knetl, Binke Mfg. Co., Chicago, Ill.; R. R. Teasdale, Gasway Corp., Chicago, Ill.; G. H. Learned, Jr., Sherwin Williams Co., Oakland, Calif.; Joe Allegretti, Masonite Corp., Chicago, Ill.; F. H. Thomas, Sherwin Williams Co., Chicago, Ill.; D. G. Lubeck, Hammond Organ Co., Chicago, Ill.

"Millions of Feet of Low-Grade Plywood will be upgraded by this equipment"

NEW REVERSE ROLL COATER

Roto Finishing Systems offers the panel-board industry a new answer to the problem of upgrading plywood and hardboards with a new type reverse-action roll coater, in 31" and 52" widths. With this machine in your shop you can pre-coat unfinished wood or plywood to a smooth prefinished surface, ready for graining or construction use as is. Handles flat or receptive surfaces.

HOW IT WORKS: The material is fed into Roller Coater. The first roller coats and fills the surface with a prepared finish, as pre-determined by the operator. When the surface reaches the reverse roll, the excess material is removed and the result is a smooth hard polish finish. Powered by two indivIdually controlled explosion-proof motors using heavy Thiakol and polished steel rollers, the reverse roll coater fills and smoothes even knotty plywood and upgrades it to higher market value with less labor. This unit may also be operated as a conventional roller coating machine.



Roto Finishing Systems produces 13 different graining and coating machines, equipment and cylinders for the woodworking industry. Write now for further information.

Roto FINISHING SYSTEMS

1501 So. Alameda St. Compton, California

Telephone: NEwmark 8-6691, if you need service.

Lumber Manufacturing Division to Contact 600 Research Organizations
Clearing House Committee to Circulate Information on Research in Progress

Milton H. Mater, Chairman, Mater Engineering, Corvalis, Ore.

The annual business meeting of the FPRS Lumber Manufacturing Division was called to order by Chairman Mater in San Francisco, California, at 2:10 P. M., July 1, 1959. The roster of members attending appears as the last page of these minutes.

The minutes of the 1958 meeting of the Division at Madison were read and accepted. Chairman Mater announced that he had appointed Paul Heller Vice-chairman of the Division. Mr. Heller was also assigned the post-card equipment survey, which will be handled on an annual basis instead of monthly.

I. Research Clearing House Committee

A change in job assignment led David J. Herrick to resign as chairman of the Research Clearing House Committee. He was replaced by Norman Taylor. Mr. Taylor reported for the Committee on his compilation of lists of research organizations working in the forest products field. Approximately 600 names on this list will be circularized in July. Volunteers are needed to work on the committee.

II. Division Officers Report

Paul Heller reported on a meeting of the Division officers, at which they recommended to the Executive Board of the Society that the constitution be amended to recognize and legalize the Divisions as subordinate organizations within the Society on a par with the Sections. Mr. Heller also summarized recommendations that pertained to: the establishment of Division officers (chairman, vice-chairman and secretary); appointing optional Division representatives to the Sections; an annual report or review to be submitted by the chairman of each Division by December 15; definite procedures (to be determined by the Executive Board) for election and tenure of Division officers. The Division officers felt that membership in a Division should be optional and open to all members of the Society.

III. Publication Problems

Lee Hooker commented on the well-known reluctance of research workers to publish preliminary findings, a tendency which often leads to long delays in publication and exchange of information. He suggested that articles be solicited for publication in the *Journal* to promote the prompt dissemination of even preliminary findings. This suggestion lead to a general discussion of the question of the backlog of papers for the *Journal*, the importance and cost of preprints of papers presented at national and sectional meetings, and the possibilities of a Division newsletter.

S. M. Batori asked that the Division try to encourage the presentation of more technical papers in its sessions, to complement the strong managerial slant of much of the material presented at the San Francisco meeting.

IV. Election of New officers

Continuing to operate under the informal and extra-constitutional procedures, the Division then went on to the election of officers. On motion by W. R. Warner, seconded by S. M. Batori, the current officers, Milton H. Mater, Chairman, Paul Heller, Vice Chairman, and H. I. Winer, Secretary, were renominated and elected by acclamation.

The meeting adjourned at 3:20 P.M.

The following members were present:

S. M. Batori, Controls & Communications Co., Eugene, Ore.; Edward C. Brown, Kirby Lumber Corporation, Silsbee, Texas; Norman C. Bye, Disston Division, H. K. Porter, Inc., Philadephia, Pa.; Maury Glassy, Radar Pneumatics, Inc., 1739 NE 42, Portland, Oregon, P. Heller, Pacific Pine Co., Ltd., New–Westminster, B.C.; Leland W. Hooker, Forest Products Division, Michigan College of Mining & Tech., Houghton, Mich.; John K. Martin, The Pacific Lumber Company, San Francisco, Calif.; M. H. Mater, Mater Engineering, Corvallis, Ore.; W. T. Pinkston, Crossett Lumber Company, Crossett, Ark.; Fred Simmons, Northeast Forest Experiment

More Douglas Fir Plywood
HAS BEEN PRODUCED ON
Williams-White Presses
THAN ON ANY OTHER MAKE

20-opening, 106" x 54", 572-ton hot plate press

Williams-White engineering leadership and manufacturing experience pay dividends in low operating and maintenance costs, high production. For free engineering consultation on presses for plywood or particle board manufacture or for laboratory work, write Customer Engineering Service. Ask for Bulletin 200-A.

WILLIAMS-WHITE & CO.
800 Third Avenue, Moline, Ill., U. S. A.

SALES AGENTS: Portland, Allied Northwest Machine Tool Co.
Seattle: Perine Machinery & Supply Co., Inc.

the measure of
Performance Reliability
for more than a century

106th year

Station, Upper Darby, Pa.; Norman Taylor, Univ. of Oregon, Eugene, Ore.; W. R. Warner, Potlatch Forests, Inc., Warren, Ark.; Irv Wentworth, Potlatch Forests, Inc., Lewiston, Idaho; Jack Werling, Univ. of Wash. and Ets. Werling (Strasbourg, France), 1201 Campus, Seattle 5, Wash; H. I. Winer, Yale Forestry School, New Haven, Conn.;

Wood Drying Division Plans Wood-Moisture Surveys to Get Wood in the Proper Use in the Right Places

John M. McMillen, Chairman, U.S. Forest Products Laboratory, Madison, Wis.

Wood Drying Division Chairman Eric Ellwood describes a technical point at business meeting.

I. Report on the Divisions News Digest

Chairman McMillen reported on the service the Division is providing kiln clubs through the continued distribution of the monthly *Digest*.

Since 1953, largerly through the efforts of R. C. Rietz, U. S. Forest Products Laboratory, 2,500 monthly copies have been distributed. These *Digests* contained condensations of talks or articles on wood seasoning and kiln operation.

It was agreed that the *Digest* performs a valuable service, and it was unanimously voted to continue it on a monthly basis.

II. Report on Organizations and Section Liaison

Harvey Smith, subcommittee chairman, Pacific Southwest Forest & Range Experiment Station, reported that there were nineteen dry kiln clubs or wood seasoning organizations active in the United States last year. It was suggested that members of the Division who are also members of these other organizations encourage cooperative technical sessions at the various Section Meetings of the Society. The Division members should also encourage more outside groups to work with the dry kiln clubs.

The "Wood and Water Meeting" held at the Carolinas–Chesapeake Sections, with Walton R. Smith as program chairman, was termed a prime example of this type of activity.

III. Report on Bylaws

The matter of proposing constitutional amendments and modifying the national bylaws to properly integrate the Divisions in the Society was discussed briefly. It was pointed out that action has been taken by the Executive Board and that proposals would be voted on at the next national meeting.

IV. Report on Abstracting Service and Status of Wood Drying Reports

Chairman McMillen reported that the Status report for February had been prepared by past chairman, Steve Preston.

The results of a questionnaire to subcommittees and past authors of the report were discussed. They showed general agreement that the two services

SARANAC Machines* can help
SOLVE YOUR PACKAGING PRODUCTION PROBLEMS!

FOR SHORT RUNS—OR SMALLER PLANTS—CHOOSE A GENERAL PURPOSE STAPLER

A heavy-duty machine, the General Purpose Stapler pays off on short or medium runs. With one or two stapling heads, it'll make *stronger* crate parts *fast,* handling a wide variety of jobs. Makes and drives its own staples direct from coils of low-cost wire. *Request Bulletin 166.*

FOR MEDIUM OR LARGE VOLUME RUNS, SELECT A CHAIN-FEED SARANAC!

For example, this chain-feed Saranac C R Machine delivers astonishing production in large plants. With a crew of 8 people, it produces 100 linear feet of cleated box panels per minute, replacing equipment costing $50,000 *more* and requiring a crew of 29 people. *Request Bulletin 167-CR.*

*A WIDE RANGE OF TYPES, SIZES . . .

Between these extremes in size and capacity, Saranac builds hundreds of models of hand-feed and chain-feed container-making machines. All cut, form and drive their own staples direct from low-cost coils of wire available almost anywhere. All offer you the greater holding power of rugged, clinched staples—and the greater dependability of Saranac-engineered design.

Write Saranac, describing your container-making problems. Send samples if possible. We'll gladly make suggestions without obligation.

SARANAC MACHINE COMPANY
BENTON HARBOR • MICHIGAN

Manufacturers of the World's Largest Line of Fastening Machinery

should be combined under one subcommittee. It was agreed that each issue of the Journal should contain two or three good abstracts, and that the status report should be a statement to forest products industries even though they are not actively engaged in seasoning. The status report should also be directed to those engaged in fundamental and applied research. Literature references should include fifty to one hundred of the most important references.

V. Report on 1959 Technical Sessions

The Division held two successful technical sessions at the annual meeting. Five technical papers were presented at one session, which was devoted strictly to wood drying. The second session was held jointly with the Lumber Manufacturing Division. One paper from the Drying Division, two papers from the Lumber Manufacturing Division, and a panel discussion were presented at the joint session. In the opinion of those who attended, the joint session was termed an excellent activity that should be repeated in the future. It was the Chairman's opinion, however, that the Drying Division should not request a joint session at the Montreal Meeting.

VI. Report on Wood Moisture Survey

The work of Walton R. Smith and Harvey H. Smith on the determination of moisture content of wood in use in various locations was discussed. Walton R. Smith called for Division sponsorship of widespread studies on this subject. He pointed out that such work would help to get wood into proper use in the right places. A subcommittee was formed to draft a working plan for the dry kiln clubs. The plan will be discussed at Montreal in 1960.

VII. Report on the Technical Movie

Subcommittee member Chris Skaar, College of Forestry, New York State University, reported for Subcommittee chairman Harold Gatslick. Skaar showed a film on the reduction of cupping of beech boards by drying them under weight. The film, made last spring, was preliminary in nature, but showed the possibilities of movie techniques. Skarr reported that the subcommittee had considered the possibilities of films on fundamental drying process, air drying, and kiln drying. The group agreed the first film should be similar to "How Wood Dries." This could be followed by films showing the mechanics of air drying and kiln drying.

Attempts to obtain financing for the film were not successful. Jim Bethel suggested the possibility of aid from the National Science Foundation, if the film could be used in college courses. In the coming year, the subcommittee will outline a fundamental film on wood drying and investigate the possibility of financial aid from foundations.

VIII. New Officers and Job Committees

Chairman, Eric L. Ellwood, University of California Forest Products Laboratory, Richmond, California; Vice-chairman, Ralph Millett, Canadian Forest Products Laboratory, Ottawa, Canada; Secretary–Treasurer, Harvey H. Smith, Pacific Southwest Forest & Range Experiment Station, Berkeley, California; Past Chairman, J. M. McMillen, U. S. Forest Products Laboratory, Madison 5, Wisconsin.

News-Digest—R. Rietz, Chairman, R. Page, C. Danielson, F. Nord, W. E. Munson, P. M. Williams, Jr.

Annual Status Report—J. M. McMillen, Chairman, S. B. Preston, and V. Clausen.

Abstracts—S. B. Preston, Chairman, H. E. Troxell, F. W. Guernsey.

Wood Drying Organizations—E. M. Conway, Chairman, H. H. Smith, W. R. Smith, C. W. Heffner, J. B. Huffman, W. J. Tomford, E. F. Rasmussen, H. B. Gatslick, J. Devine, and C. J. Kozlik.

Wood Drying Film—J. I. Zerbe, Chairman, W. B. Wallen, N. C. Higgins, L. Leney, and C. Skaar.

Wood Moisture Survey—J. Bethel, Chairman, W. Smith, and H. Smith.

Other Committee Members—W. J. Delmhorst, R. H. Elliott, A. C. Knauss, J. D. Irwin, and D. B. Richards.

The chairman adjourned the meeting at 5:25 p.m.

THE TAYLOR PANEL-FLO* for Modern, Up-To-Date Continuous Edge Gluing

Panel-Flo with single feed; part time operation; 3500 square feet daily.

Tom Govern, progressive manager of Catskill Craftsmen of Stamford, New York, likes his Panel-Flo *Steam-curing Continuous Gluing* Machine because it makes invisible joints in his glued *Adirondack Maple*-All *face stock*, with culls at a minimum. After two years Mr. Govern reports.. no down time, no upkeep expense and extremely low gluing cost.

Investigate and save with a Panel-Flo.

*Reg. U. S. Pat. Off.

FREE BOOKLET: Write today for your copy of "The Taylor Panel-Flo Continuous Edge Gluing Machine," a booklet which explains the engineering advancements accompanying this new, revolutionary method of Continuous Edge Gluing.

James L. Taylor Mfg. Co.

Edge Gluing Specialists Since 1900

112 PARKER AVE., POUGHKEEPSIE, N. Y.

Wood Preservation Division Plans Half-Day Session at Montreal Meeting

C. S. Walters, Chairman, University of Illinois, Urbana, Ill.

The meeting was called to order by Chairman Walters at the St. Francis Hotel, San Francisco. Only six members were present.

I. New Officers

Frank Kaufert, chairman of the nominating committee, reported that Ralph Bescher, Koppers Company, Inc., Wood Presrving Division, Pittsburgh 19, Pa., was recommended as candidate for chairman and that Harry E. Troxell, Jr., School of Forestry, Colorado State University, Ft. Collins, Colo., was recommended for vice-chairman.

The candidates were approved by a majority vote, and their names were submitted to the Executive Board for approval.

II. Business Meeting

Chairman Walters pointed out that the small attendance indicated that most members were not sufficiently interested in the meeting to attend.

He stated that special effort is needed to stimulate interest in Division affairs. It was suggested that the business meeting occupy a portion of the technical program. This would enable the Division to select officers and plan the technical program with a quorum of reasonable size.

III. Annual Meeting 1960

The group voted to have a half-day technical session at the 1960 meeting in Montreal. It was suggested that: (1) the session be limited to four technical papers and that two of them should have Canadian authors; (2) the papers be technical in nature and not more than one survey-type paper should be approved.

IV. Annual Report

Chairman Walters reported the annual report is being written and that he needs material. More than 40 persons have been contacted for information. The first draft of the report was schedued for September.

exact control

in blanking and finishing rough squares

Blank out rounds at high feed speeds and get best surface finish on any wood with Hawker's control of cutter speeds and feeds. No chatter, spinning or twisting. Self-centering infeed guide plus horizontal and vertical outfeed rolls hold stock firmly during cutting! Easy adjustment gives minimum down time. Semi-automatic hopper feed for continuous high production.

Perfectly balanced, match-ground knife sets are maintained by using a Hawker precision cutter knife grinder.

Demonstrations arranged in your plant—or let us refer you to a customer near you. Write for manual on the new Model 1000. The Hawker Manufacturing Division, East Dayton Tool & Die Co., 1425 Keowee Street, Dayton 4, Ohio.

HAWKER

MACHINE TOOLS FOR WOODWORKING

Wood Machining Division Considers Presentation of Russian Film Plans to Survey Recent Foreign Developments Work on Wood Machining Abstracts to Be Continued

N. C. Bye, Chairman, Henry Disston Division, H. K. Porter Co., Philadelphia, Pa.

The meeting was called to order in San Francisco, July 1, 1959. The minutes of the 1958 meeting were read and approved.

I. New officers

Mr. Robert J. Hoyle, Jr. will serve as Chairman of the Division for this period, and Dr. Norman C. Franz will act as Vice-Chairman. Dr. James Lubkin will serve as Secretary for the coming year.

II. Members of Steering Committee

This committee was activated last year to support the overall activities of the Division. Several names were added to this list, which is now as follows: C. A. Baker, H. L. Bennett, C. P. Berolzheimer, Linn Brown, N. C. Bye, E. M. Davis, K. C. Compton, P. F. DeSaix, Sterling Durst, A. Feldman, N. C. Franz, Dewey Gommel, W. C. Hagstrom, Robert J. Hoyle, Jr., E. S. Johnson, Peter Koch, Lawrence Leney, J. L. Lubkin, A. M. Mattison, Robert Miller, L. A. Patronsky, J. C. Petter, L. H. Reineke, Rex Reynolds, Alvin Stauber, T. C. Weill, K. V. White, W. B. Wilkins.

Business meeting of Wood Preservation Division.

Industry-Education Division Chairman Jim Bethel introduces John Zerbe of NLMA.

III. 1960 Program Chairman

Dr. N. C. Franz was appointed Program Committee for the 1960 Meeting in Montreal, Canada. R. W. Perkins and Robert Chateauneuf will cooperate with him in formulating the program.

IV. Montreal Meeting

A firm list of papers is desired by Feb. 15, 1960. One technical session will be requested for wood machining. Amongst the suggestions advanced to assist Dr. Franz are the following: (a) that he contact L. H. Reineke for a brief survey of recent foreign developments, and (b) that he discuss with Eric Anderson the suitability for presentation of the Russian film on wood machining, the translation of which has recently been completed.

V. Standardization Committee

The Chairman of this committee has received the files containing the previous work on saw and knife nomenclature stnadardization. After reviewing this, appropriate plans will be drawn for the next phase of work.

VI. 1959 Annual Report

This will be sent to Mr. Frank Rovsek by N. C. Bye.

VII. Wood Machining Abstracts

A motion was made and carried to continue the good work of this committee, which consists of: Chairman C. W. McMillin, Norman Franz, Lawrence Leney, Robert Hoyle, Jr., R. W. Perkins, Mr. Frank Rovsek will be requested to undertake the printing and distribution of copies of the abstracts.

VIII. ASTM Wood Machining Standards

The ASTM has published a proposed "Tentative Methods of Conducting Machining Tests of Wood and Wood-Base Materials," which has been called to the attention of the Division. A motion was made and carried for the Chairman to submit the Division's comments (if any) to the ASTM.

IX. NORTHEAST SECTION October Meeting

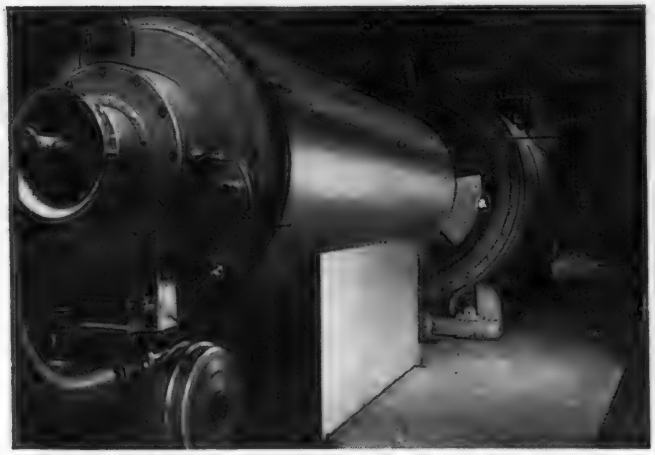
The request of J. Alan Hauter, Chairman of the Northeast Section, for papers for the October meeting will be referred to Program Chairman, N. C. Franz.

Those present were:

C. W. McMillin, AMF, P. O. Box 889, Stamford, Conn.; C. P. Berolzheimer, California Cedar Products Co., P. O. Box 528, Stockton, Calif.; N. C. Bye, Disston Div., H. K. Porter Co., Philadephia, Pa.; J. Lubkin, AMF, P. O. Box 889, Stamford, Conn.; L. Leney, School of Forestry, Univ. of Missouri, Columbia, Mo.; A. Juram, Disston Div., H. K. Porter Co., Philadelphia, Pa.;

SHAVINGS TO PARTICLE BOARD . . .

AUTOMATICALLY!



Fast, Uniform Drying of Wood Products

Your wood chips, flakes, shavings or sawdust can be dried uniformly in a matter of seconds by a HEIL Dryer — then pressed into high-quality board.

The dryer uses a flow of hot air to carry material through the three-pass drum. Small particles move through quickly . . . heavier particles with more moisture content move slower. Both heavy and light materials are dried uniformly.

Compound showering flights on drying drums eliminate surging . . . keep particles flowing in the hot air stream.

Write, wire or call for further information.

AT Brownsville, Oregon, 20 truckloads of green Douglas fir shavings are converted into six carloads of high-quality particle board weekly in an operation described as "automation in practice." The Brownsville Particleboard and Associated Products, Inc., plant completes the entire process with two 9-man crews and *only two* manual handling chores. A HEIL Dryer reduces moisture content of the material to about six percent.

The Arnold Dryer Co., subsidiary of

THE HEIL CO.

3000 W. Montana Street, Milwaukee 1, Wisconsin

Wood Composition Board Division to Discuss Particle Board Standards at Montreal Meeting, 1960

James R. Roberts, Chairman, The Celotex Corp., Des Plaines, Ill.

I. Status of Divisions

Mr. Allegretti outlined the procedure developed by the Board of Directors to formalize the status of the Divisions within the Society.

II. Election of Officers

It was moved by Wayne C. Lewis and seconded by Walt Noble that the present officers be retained for the next year or until such time as the new procedures for Divisions are adopted. The motion was passed, and a recommendation will be sent to the Executive Board.

III. Steering Committee

George G. Marra presented the nomination of Max Yan to the Steering Committee. The group agreed that it shoud be so recommended to the Executive Board.

Mr. Hamilton presented a Steering Committee proposal that a session of the next meeting be devoted to discussion of standards for particle board.

V. New Subjects

In open discussion the group agreed that the following subjects deserved future consideration: (1) fire-resistance evaluations, (2) requirements of surface finishes, (3) small tests versus large ones, (4) edge treatments, and (5) roof-deck slabs.

VI. Panel Discussion

It was suggested that the Panel Discussion failed because it lacked stimulation. It was recommended that a member in the audience be selected to start the discussion with a specific question, and the reply should be formulated in advance.

The meeting was adjourned.

Veneer and Plywood Division Seeks Paper on "New Way to Make Plywood"

J. L. Butler, Chairman, Reichold Chemicals, Inc., Charlotte 3, N. C.

The meeting was called to order by Vice-Chairman John F. Lutz, July 1, 1959.

I. Nominating Committee

A nominating committee consisting of Richard Petterson, Jim A. Mueller, and H. A. Fleischer, chairman, proposed the following for officers of the Division: John F. Lutz, chairman, and Tom Batey, vice chairman. There were no further nominations and the candidates proposed by the nominating committee were unanimously elected.

II. National Meeting

The presiding chairman reported that the next annual meeting would be held in Montreal June 5 to 9, 1960. The meeting was thrown open to discussion as to the type of program desired.

Jack Grantham suggested limiting the program to three papers.

E. Hobert Collins suggested a paper on possible future method of making plywood. It was further suggested that a speaker from some other industry might be able to give such a talk.

Several members suggested returning to the use of reprints even if they had to pay for them. Frank Rovsek commented that the cost of 50 preprints would be about $3.00.

It was suggested that the next national meeting again have a diversified program .

The following members were present:

A. C. Knauss, Pacific Northwest Forest & Range Experiment Station, Portland, Ore.;

Complete Service On Wood Preservatives!

TECHNICAL COUNSEL
A full staff of specialists with years of experience and complete laboratory facilities, ready to assist in every way.

ENGINEERING SERVICE
An experienced engineering department to help in planning, designing and installing new pressure-treating plants; modernizing old plants; selecting equipment to meet your specific needs.

WOODTOX Penta Preservative and Water Repellent
A clear, clean, non-staining treatment combining advantages of Penta plus resistance against swelling, warping, shrinking and other moisture damage. Meets NWMA and Western Pine Assoc. preservative standards.

PENTAchlorophenol WOOD PRESERVATIVES
Most satisfactory and permanent of all wood preservatives against decay, fungi, termites and other wood boring insects.

NOXTANE SAP STAIN CONTROL
Most effective, safe and economical treatment made for protection against sap stain fungi. Leaves wood bright and clear. Quick solubility, dustless, non-irritating. Won't damage metal equipment.

EQUIPMENT
Exclusive national sales agents for Efurd Machine & Welding Company, builders of Hurricane Debarkers, Peelers, Framers, Incisors, Trams, etc.

Whatever your problem in the protection and preservation of forest products, this is where you can always get the *right answers quick!* Write or phone.

WOOD TREATING

WOOD TREATING CHEMICALS CO.
5137 Southwest Avenue St. Louis 10, Missouri

E. W. Wellwood, Canadian Forest Products, New Westminster, B.C., Canada; H. O. Fleischer, U. S. Forest Products Laboratory, Madison, Wis.; F. Rovsek, Forest Products Research Society, Madison, Wis.; Claus R. Sutor, Aetna Plywood, Chicago, Ill.; E. Hobart Collins, Weyerhaeuser Timber Co., Kelso, Wash.; H. W. Berry, Douglas Fir Plywood Association, Tacoma, Wash.; B. R. Jones, U. S. Plywood, Redding, Calif.; John D. Fair, U. S. Plywood, Redding, Calif.; John F. Lutz, U. S. Forest Products Laboratory, Madison, Wis.;

Logging Division Cites Lack of Basic Research on Logging —Will Promote and Encourage Basic Studies to "The Very Limit Possible"

Fred C. Simmons, Chairman, Northeastern Forest Experiment Station, Upper Darby, Pa.

The meeting was called to order at the St. Francis Hotel, San Francisco, Calif., at 3:00 p.m. July 1, 1959.

I. Nominating Committee

Chairman Simmons announced his retirement after three years as Division Chairman and a previous three years as Chairman of the Logging and Milling Subject Matter Committee.

The following slate of officers was presented by the nominating committee:

Chairman, L. N. Ericksen, Chief, Division of Forest Utilization Research, Pacific Southwest Forest Experiment Station, Berkeley, Calif.

Vice-chairman, J. A. Doyle, Head, Wood Utilization Division, Forest Products Laboratories of Canada, Ottawa, Ontario, Canada.

Secretary, George Stenzel, University of Washington, Seattle, Wash.

The slate was unanimous approved and the Chairman was instructed to recommend it to the President.

II. Technical Session

It was unanimously decided that the Division sponsor a technical session at the Annual Meeting in Montreal, Canada, in 1960. J. A. Doyle was appointed program chairman.

III. Division Program for the Future

Leland Hooker presented an approach to the future program of the Division which would promote and encourage basic research studies in logging to the very limit possible. He emphasized the enormity of the total logging job in the United States, saying that the total volume, weight, and distance of forest products movement in the country exceeds that of coal, iron ore, or an other commodity except dirt. The complexity of the problems in movement of forest products was also said to be greater than that of other materials, because of their location in remote mountain areas, swamps, etc. Yet the equipment manufacturers and the engineering profession generally have not devoted anywhere near the attention to the problems of logging as they have to those of these other industries. The reasons for this are undoubtedly that the forest products industry is typicaly made up of small business units, and also the very complexity of the problems with which it is confronted.

Even publicly-supported institutions, such as the U. S. Forest Service, are devoting very little attention to basic research in logging problems. Mr. Hooker cited Dave Herrick's study on skidding resistance of logs (reported in the *Forest Products Journal*, 1955, Vol. V, No. 4, p. 250) as about the only example of such research by the Forest Service he could recall. Relatively little work is being done along this line by the colleges and universities.

It was agreed that there is a great need for basic reesarch in logging, and that the Division should do everything in its power to emphasize this need, and to encourage additional needed studies by agencies and institutions equipped to conduct them. The Division will, of course, provide a means

Automatic Sizers for Doors and Board Materials

KVAL NO. 440BD

Inquire

KVALHEIM MACHINERY CO.

823–825 Petaluma Blvd., So.

PETALUMA, CALIF.

Say you saw our ad in Forest Products Journal

Let's face it, HOMER,

The automobile has replaced the horse and buggy

JUST AS STRONGHOLD® AND SCREW-TITE® THREADED NAILS ARE FAST REPLACING OLD-FASHIONED SMOOTH SHANK NAILS

THE OLD GRAY MARE that tugged on the whiffletree has gone the way of the dodo. The automobile is here to stay. *And so are* STRONGHOLD *and* SCREW-TITE *Threaded Nails.*

These "new fangled" nails are no longer a novelty. They've met the test of a quarter of a century of use. Architects specify them. Leading builders, contractors, fabricators use them by the millions of pounds a year.

They make house frames up to 5.7 times as strong —keep wood floors and underlayment smooth, tight, squeak-free — virtually eliminate "popping" nail heads that mar beautiful gyspumboard drywall — hold shingles secure in winds up to three times hurricane force. They make new cost-saving methods practical — permit you to use shorter nails, slimmer nails, fewer nails; save time, labor, material; cut maintenance costs; give freedom from customer complaints. *No wonder they've revolutionized construction methods!*

Scientifically engineered threads "lock" with the wood fibres. STRONGHOLD and SCREW-TITE Nails hold *permanently* tight—gain holding power after driving as the wood seasons.

Actual samples of nearly 50 different types of STRONGHOLD, SCREW-TITE and other special nails are shown on this display board. Sent free to dealers, distributors, architects, teachers.

Always ask for "Stronghold" or "Screw-Tite" Nails by *name*. Do not accept substitutes. Write us for samples, literature, technical data.

"Drives Like a Nail— Holds Like a Screw"

THE Stronghold Line
BETTER FASTENINGS FOR EVERY PURPOSE

© Copyright I. N. & P. Co., 1959. Trade Marks Reg. U S. Pat. Off.

There is only one STRONGHOLD Line—the Original. Made only by

INDEPENDENT NAIL & PACKING CO.

Pioneer Developers and Largest Manufacturers of Threaded Nails

BRIDGEWATER, MASSACHUSETTS, U.S.A.

for publicizing progress and results in such studies through its technical sessions, and articles in the *Journal*.

IV. Steering Committee

Chairman Simmons explained that the proposed amendment to the Constitution of the Society, "Legitimizing" the Divisions.

The following members attended the meeting:

A. B. Recknagel, St. Regis Paper Co., Ithaca, N.Y.; John Howe, University of Idaho, Moscow, Idaho; Leland Hooker, Michigan College of Mining and Technology, Houghton, Mich.; Herbert Winer, Yale University School of Forestry, New Haven, Conn.; L. N. Ericksen, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.; and Fred Simmons, Northeastern Forest Experiment Station, Upper Darby, Pa., Chairman.

Quality Control Division Considers Broader Scope

A. E. Wylie,
Chairman, Michigan State Univ.

Chairman Wylie announced that he is leaving the United States for a six-month period and will not be able to carry on the duties of the Chairmanship.

Dr. Wylie mentioned that there was a problem of legalizing the Division and also election of new officers. Dr. Wylie proposed that nominations and the election be postponed until availability of people to serve could be determined.

Vice Chairman Aubrey Wylie conducts Quality Control Division business meeting.

Several proposals have been offered for broadening the scope of subject matter of the Quality Control Division. As a result of the discussion concerning this problem, the following factors were considered:

1. Keep the emphasis on statistical quality control.
2. Widen the range of subject matter to "operations research".
3. Continue to emphasize new techniques and methods, keeping work on an advanced level. Let the educational institutions and service organizations do the job of adopting the methods for specific applications.
4. Devote efforts to bringing statistical control tools to the level of the operating man in the industries.
5. Send a question sheet to all FPRS members who checked *quality control* on the preference card, which was sent from Madison. Ask what the individuals believe the scope of the Section shall be.

The general consensus of opinion of the men present at the business meeting was that we should continue to explore new methods and advanced techniques that can be applied to the wood industries.

New Officers

The following suggestions for officers of the Quality Control Division were offered: Dr. J. R. Stillinger, Cascades Plywood Corporation, Lebanon, Oregon; and, Mr. Burr Matson, Simpson Logging Company.

List of F.P.R.S. Members Attending Business Session Quality Control Division

Alan C. Goudy, Collins Pine Company, Chester, Calif.; James W. Johnson, Oregon Forest Products Research Center, Corvallis, Ore.; Harry W. Demaray, Pope & Talbot, Inc., Oakridge, Ore.; William W. Glover, Oregon Forest Products Research Center, Corvallis, Ore.; David M. Hancock, California Water Resources, Sacramento, Calif.; George Smith, N. C. State College, Raleigh, N. C.; W. C. Ring, International Paper Company, Long Bell Division, Longview, Wash.; T. A. Getsiv, Weyerhaeuser Timber Company, Longview, Wash.; C. M. Keaton, American-Marietta Company, Seattle, Wash.; A. E. Wylie, Michigan State University, East Lansing, Mich.; and J. R. Stillinger, Cascades Plywood Corporation, Lebanon, Ore.

One-man high frequency gluing line increases production 300%!

The new Union High Frequency Gluing Line is actually *three times faster* than clamp-type gluing methods. It slashes labor costs too, because one man can handle the entire job unassisted.

Here's how this unique system works: Stock is loaded in automatic hopper which feeds it through a roller coater applying a smooth coat of glue. When stock reaches the conveyor end, a cut-off micro switch stops the line. Glued stock is then placed on the pivot table of the Union ROTO-GLUER® in which glue is cured by high frequency energy. While one end is under the electrodes, operator unloads and reloads other end . . . production is continuous.

Priced at under $10,000, the Union High Frequency Gluing Line is ideal for use in small and medium sized furniture plants. Write for details about this production-boosting system today.

900 North Detroit Street

THE UNION TOOL CORPORATION
WARSAW, INDIANA

UNION-WALLACE-INDIANA
A MANUFACTURING GROUP
DEVOTED TO PRODUCING
THE HIGHEST QUALITY
WOODWORKING MACHINES

Hallmark of Quality since 1863 . . .

You Get Machines!
Not Toys!
from "Challoner"

"Challoner" No. 527T D. E.
Tenoner with Dado Arbor

The New "Challoner" #527T
is made for the various
tenoner attachments.

Manufactured by C. K. L. MACHINERY CO.
OSHKOSH, WISCONSIN

This mark identifies the finest bench presses ever made. If you need a hydraulic bench press, write for circular or if you prefer we'll have our nearest representative call on you...

PHI PRESS
formerly Preco

PASADENA HYDRAULICS, INC.
1431 Lidcombe El Monte, Calif.

NEWMAN G-20

GRINDS
PLANER
CHIPPER
AND HOG
KNIVES

DOUBLE
KNIFE
BARS

Full rotary action. Non reciprocating.

Continuous grinding motion for wet or dry grinding.

Grinds 8 knives at one operation.

Automatic

Knife Grinder

The NEWMAN G-20 is recommended for precision grinding of planer knives and all types of knives which can be ground by making a straight pass across the face of the knife. Will grind 8 knives 20" long or 6 knives 27" long, 160 inches of knives can be ground in floor space 42" x 43".

NEWMAN MACHINE CO. INC.
Greensboro North Carolina U.S.A.

Know Your FPRS Officers and Committees

Members of National Executive Board ,l. to r.) Frank J. Rovsek, Executive Secretary; T. S. Veazey, Northwest Regional Board Member; W. Jeter Eason, past president; Don K. Saunders, Vice President; E. S. Harrar, President; Raymond Berry, President-Elect; Walton R. Smith, Southeast Regional Board Member and James L. Love, South Central Regional Board Member. Not present when this photo was taken Southwest Regional Board Member Fred E. Dickinson and Northeast Regional Board Member Col. John H. Jenkins.

WITH A MEMBERSHIP of over 3900 persons as this Yearbook issue goes to press, the national work of FPRS is administered by an elected Executive Board comprised of four officers and six regional board members. The sectional, regional, and committee work is governed by more than 300 persons.

Executive Officers

President—E. S. Harrar, School of Forestry, Duke University, Durham, North Carolina.

President-Elect—R. H. Berry, Scott Lumber Company, Inc., Burney, California.

Vice-President—D. K. Saunders, Saunders Brothers, Westbrook, Maine.

Past President—W. J. Eason, Nickey Brothers, Inc., 2700 Summer Avenue, Memphis 12, Tenn.

Executive Secretary—F. J. Rovsek, Forest Products Research Society, 417 N. Walnut St., Madison 5, Wisconsin.

Regional Board Members

North Central—J. J. Allegretti, Masonite Corporation, 111 West Washington Street, Chicago, Illinois.

Southwest—F. E. Dickinson, Forest Products Laboratory, 1301 South 46th Street, Richmond 4, California.

Southeast—Walton R. Smith, Southeastern Forest Experiment Station, P.O. Box 2570, Asheville, North Carolina.

Northeast—Col. John H. Jenkins, Forest Products Lab. of Canada, Dept. of Northern Affairs & National Resources, Ottawa, Ontario.

Northwest—T. S. Veazey, Jr., The Anaconda Company, 10 East Quartz Street, Butte, Montana.

South-Central—James L. Love, Love Wood Products of Texas, Box 277, Diboll, Texas.

SECTION OFFICERS

CAROLINAS–CHESAPEAKE

Chairman—Kenneth Redman, Redman Associates, Inc., P.O. Box 1820, High Point, North Carolina.

Vice Chairman—John B. Hayward, 500 Sunset Drive, High Point, North Carolina.

Sec.–Treas.—George Smith, School of Forestry, North Carolina State College, Raleigh, North Carolina.

Past Chairman—James S. Bethel, National Science Foundation, Washington 25, D. C.

Trustee—P. F. DeSaix, Route 5, High Point, North Carolina.

Trustee—William Early, Lilly Company, 700 W. Lexington Avenue, High Point, North Carolina.

Trustee—Rowland Garratt, Timber Engineering Co., 4812 Minnesota Ave., NE, Washington, D. C.

Trustee—Joseph Shuman, Darlington Veneer Co., Darlington, S. C.

Trustee—Michael T. Taras, Southeastern Forest Exp. Sta., School of Forestry, N. C. State College, Raleigh, North Carolina.

Membership Chairman—T. D. Johnson, Reichhold Chemicals, Inc., P.O. Box 3715, Charlotte 3, North Carolina.

EASTERN CANADIAN

Chairman—R. F. DeGrace, Canadian Institute of Timber Construction, 140 Wellinton Street, Ottawa, Ontario, Canada.

First Vice Chairman—Clayton Allgeier, Dom. Electrohome Ind., Ltd., Kitchener, Ontario, Canada.

Second Vice Chairman and Membership Chairman—J. David Irwin, University of New Brunswick, Fredericton, New Burnswick, Canada.

Secretary—E. L. Fowler, 27 Goul Bourn Avenue, Ottawa, Ontario, Canada.

Treasurer—J. A. Doyle, Forest Products Laboratories of Canada, Montreal Road, Ottawa 2, Ontario, Canada.

Past Chairman—G. S. Billinton, Moore Dry Kiln Co., Ltd., P. O. Box 707, Brampton, Ontario, Canada.

Trustee—G. E. Bell, Sec. Mgr., Canadian Lumbermen's Ass'n., 27 Goulbourn Avenue, Ottawa, Ontario, Canada.

Trustee—R. M. Dorland, Central Res. & Development Division, Abitibi Power & Paper Co., Ltd., Sault Ste. Marie, Ontario, Canada.

Trustee—F. J. Riley, Editor, Canada Lumberman, 1450 Don Mills Road, Don Mills, Ontario, Canada.

Trustee—J. Howard Langstaff, c/o Monsanto Canada, Ltd., 425 St. Patrick Street, Ville LaSalle, P. Q. Canada.

Trustee—R. G. Miller, International Plywoods, Gatineau, Quebec, Canada.

Trustee—Philippe R. LeSage, 4427 Melrose Avenue, Montreal 28, P.Q., Canada.

GREAT LAKES

Chairman—S. W. Tamminga, V. P., Hekman Furniture Co., 1400 Buchanan Ave., SW, Grand Rapids 2, Michigan.

Vice Chairman and Membership—E. Brooks Applegate, Travis–Applegate Company, 714 Building & Loan Building, Grand Rapids 2, Michigan.

Secretary—Norman C. Franz, University of Michigan, 3311 Dale View Drive, Ann Arbor, Mich.

Treasurer—George Tasker, 20833 Travers Street, Chicago Heights, Ill.

Trustee—Hereford Garland, Mich. College of Mining & Tech., Houghton, Mich.

Trustee—G. G. Garlick, Dir. of Res., Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

Trustee—Wayne F. Hutchins, Research Dept., American Seating Company, Grand Rapids, Michigan.

Trustee—Alexis J. Panshin, Head, Dept. of Forest Products, Michigan State University, B–4 South Campus, East Lansing, Mich.

Trustee—Stephen B. Preston, University of Michigan, Ann Arbor, Michigan.

INLAND EMPIRE

Chairman—C. M. Kreider, Asst. Mgr., Brooks–Scanlon, Inc., Bend, Oregon.

Vice Chairman—I. W. Wentworth, 621 S. 14th Street, Coeur d'Alene, Idaho.

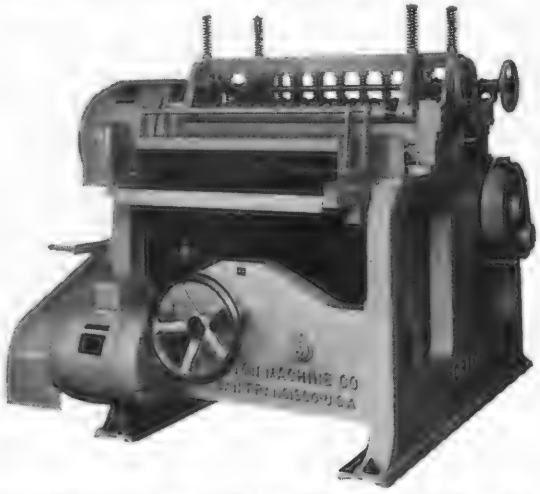
Sec.–Treas.—John P. Howe, University of Idaho, Moscow, Idaho.

ORTON

TRAVELING BED FEED

DISTINGUISHES OUR

ORTON Type C, Heavy Duty, End. Bed Sgl. Surfacer.
ORTON D-1, Cabinet, Endless Bed Single Surfacer.
ORTON D-1, Gang Straight Edge Rip Saw.



ORTON D-1, GANG STRAIGHT EDGE RIP SAW

ORTON MACHINE CO.

Established 1886
Office and Works

390 FREMONT SAN FRANCISCO 5

Universal TIME-PROVEN DOOR CARRIERS

The Original
"DRY KILN DOOR CARRIER"
Famous The World Over Since 1904

For Fast, One Man Operation of Dry Kiln Doors

Yes, *one man* can easily open or close a kiln in a few seconds!—using a Universal Door Carrier. And, good tight closures—every time—are assured by *automatic cam-action locks*. What's more—your *doors* last longer, because the Carrier saves them from destructive bending, twisting, straining, and slamming. As for durability of the Universal equipment itself, some of our *first* "Dry Kiln Door Carriers" are still in regular use after *a half-century of service*. Let our factory representative give you full details—without obligation.

OUR EXCLUSIVE LINE INCLUDES:
Doors—Carriers—Parts. (1) The perfected original "Dry Kiln Door Carrier"; (2) The best, insulated all-metal kiln doors ever built—bar none! (3) Genuine factory replacement parts.

Universal DOOR CARRIER, INC. 1117 CORNEL INDIANAPOLI

Specialists in Kiln Closure Equipment — Since 1904

There is a reason why BILT-WELL WOOD WORK REG. U. S. PAT. OFF. is a leader!

This is the modern plant where Bilt-Well Woodwork is "groomed" for its leading role in the building programs of today. Master craftsmen, research engineers and industrial designers pool their ideas in the scientific development of building products making it possible to produce a high standard of quality. The popularity of Bilt-Well Woodwork today stems from an enviable reputation built up in the past 93 years.

CARADCO, INC. Dubuque, Iowa

FORMERLY CARR, ADAMS & COLLIER COMPANY

Build Well with BILT-WELL WOOD WORK

BILT-WELL LINE: WINDOW UNITS—Double hung, Casement, Awning, and Basement • **DOORS**—Exterior, Interior, Screen and Combination • **CABINETS**—Kitchen, Storage, Wardrobe, Vanity-Lavatory, etc.

Membership Chairman—William R. Walker, Pacific Power & Light Company, Public Service Building, Portland, Oregon.

Trustee—H. R. Dix, The Anaconda Company, Bonner, Montana.

Trustee—Melvin R. Knudson, J. Neils Lumber Company, Libby, Montana.

Trustee—Ross McNett, Pres., Biles Coleman, Inc., Omak, Washington.

Trustee—William G. Walker, Pacific Power & Light Co., Portland, Oregon.

Trustee—Wyman Zachary, Browns Tie & Lumber Co., McCall, Idaho.

MID-SOUTH

Chairman—R. D. McCrite, 1032 Marcia Road, Memphis, Tennessee.

Vice Chairman—H. Dale Turner, 10 Sunset Extension, Laurel, Mississippi.

Sec'y.-Treas.—Paul Kay, 981 South 8th Street, P. O. Box 57, West Memphis, Arkansas.

Trustee—Dr. William Hopkins, School of Forestry, La. State University, University Station, Baton Rouge, Louisiana.

Trustee—Joe C. Denman, Diboll, Texas.

Trustee—Edwin Y. Wheeler, Oklahoma State University, Dept. of Forestry, Stillwater, Oklahoma.

Trustee—G. R. Twyman, Mississippi Products, Inc., Jackson, Mississippi.

Membership Chairman—Mark M. Lehrbas, Southern Forest Exp. Station, 2026 St. Charles Ave., New Orleans, La.

MIDWEST

Chairman—Robert Archambeault, 2205 Douglas Street, Joliet, Illinois.

Treasurer—Kenneth Kimball, c/o U. S. Forest Prod. Lab., Madison 5, Wisconsin.

Trustee—J. J. Allegretti, Masonite Corporation, 111 West Washington St., Chicago, Ill.

Secretary—Roy Newstedt, Wurlitzer Company, DeKalb, Illinois.

Trustee—Gustave Barshefsky, 5315 North Bernard St., Chicago 25, Ill.

Trustee—H. James Gill, Jr., Mgr., Prod. Dev., Caradco, Inc., Dubuque, Iowa.

Trustee—Dr. Ira Hatfield, Wood Treating Chemicals Co., 5137 Southwest Ave., St. Louis 10, Missouri.

Trustee—Jack Koellisch, c/o Wood & Wood Products, 59 E. Monroe St., Chicago 3, Ill.

Trustee—T. Walter Noble, Decar Plastic Corp., University Ave., Middleton, Wis.

NORTHEAST

Chairman—J. Allan Hauter, Allan Products Co., Oradell, New Jersey.

Vice Chairman—Richard F. West, Head, Forestry Dept., College of Ag., Rutgers Univ., New Brunswick, N. J.

Sec.-Treas.—Donald Pierce, Maine Skever & Dowel Corp., Farmington, Maine.

Trustee—Dana R. Bergh, Bergh Lumber Corp., Great Barrington, Mass.

Trustee—William T. Nearn, Pennsylvania State University, University Park, Pennsylvania.

Trustee—William J. Delmhorst, Delmhorst Instrument Co., 607 Cedar St., Boonton, New Jersey.

Trustee—Fred C. Simmons, U. S. Forest Exp. Station, Upper Darby, Pennsylvania.

Trustee—Frederick F. Wangaard, Yale University, New Haven, Connecticut.

Trustee—Frank T. Parrish, Heywood–Wakefield Co., Central St., Gardner, Mass.

Membership Chairman—Robert Gill, Peter Cooper Corporation, Gowanda, New York.

Past Chairman—Eric A. Anderson, New York State College of Forestry, Syracuse 10, N. Y.

NORTHERN CALIFORNIA

Chairman—Leyden N. Ericksen, Pac. SW Forest & Range Experiment Sta., P. O. Box 245, Berkeley 1, California.

Vice Chairman—Victor H. Clausen, Simpson Redwood Company, P. O. Box 35, Arcata, California.

Sec'y.-Treas.—David L. Brink, U. C. Forest Products Laboratory, 1301 South 46th Street, Richmond, California.

Past Chairman—N. T. Shelton, The Diamond Match Company, P.O. Box 1037, Chico, Calif.

Trustee—A. B. Hood, Ralph L. Smith Lumber Co., Anderson, California.

Trustee—Byrne Manson, Simpson, Redwood Company, Arcata, California.

Membership Chairman—Victor S. Roth, Triangle Lumber Company, 610 Sixteenth Street, Oakland 12, Calif.

OHIO VALLEY

Chairman—Sterling Durst, Gamble Bros., 4600 Almond Avenue, Louisville, Ky.

Vice Chairman—Henry A. Espel, Baldwin Piano Co., 1801 Gilbert Avenue, Cincinnati 2, Ohio.

Sec.-Treas.—Jerome F. Habig, Box 47, Jasper, Inidana.

Trustee—Harold E. Cook, 1019 Springdale Drive, Jeffersonville, Indiana.

Trustee—William C. Seng, Jr., Forest Prod. Mfg. Co., P.O. Box 68, Jasper, Indiana.

Membership Chairman—Harold E. Cook, 1019 Springdale Drive, Jeffersonville, Indiana.

PACIFIC NORTHWEST

Chairman—P. L. Northcott, Res. Forester, c/o Forest Prod. Lab. of Canada, Univ. of B. C. Campus, Vancouver 8, B.C., Can.

Vice Chairman—W. R. Francis, 720 South 8th St., Shelton, Washington.

Secretary—E. H. Clarke, 2333 N.E. 25th Avenue, Portland 12, Oregon.

Treasurer—Don Burnet, Crown Zellerbach Corporation, 457 N. W. Fargo, Camas, Washington.

Past Chairman—John H. Syme, Development Director, Edward Hines Lbr. Co., Hood River, Oregon.

Trustee—W. I. West, School of Forestry, Oregon State College, Corvallis, Oregon.

Trustee—E. M. Williston, Mgr. Technical Center, Weyerhaeuser Timber Company, Longview, Washington.

Membership Chairman—Earl T. McCarthy, 4315 E. 38th Street, Seattle 5, Washington.

PACIFIC SOUTHWEST

Chairman—W. E. Ripley, Jr., 16224 Rutherglen St., Whittier, Calif.

Vice Chairman—Joe H. Miller, Reichhold Chemicals, Inc., P. O. Box 22, Azusa, California.

Sec.-Treas.—Olaf Anderson, Weber Showcase & Fixture Co., P. O. Box 11065, Kearney Sta., Los Angeles 11, Calif.

Trustee—Fred Card, 1616 Encino, Monrovia, Calif.

Trustee—Joe Richardson, 11682 Gilbert Street, Garden Grove, Calif.

ROCKY MOUNTAIN

Chairman—Robert S. Bader, 142 Broadway, Denver 3, Colorado.

Vice Chairman—H. E. Troxell, Jr., School of Forestry, Colorado State University, Ft. Collins, Colorado.

Sec.-Treas.—Philip M. Opsal, 1312 Lakewood Drive, Fort Collins, Colorado.

Trustee—Lincoln A. Mueller, Rocky Mt. Forest & Range Exp. Sta., Forest Bldg., Fort Collins, Colorado.

Trustee—T. W. Schomburg, 1856 Colo. Blvd., Denver 20, Colo.

Membership Chairman—Alan Miller, Amer. For. Prod. Ind., Inc., 401 Ross Bldg., 1726 Champa St., Denver 2, Colorado.

SOUTHEASTERN

Chairman—William Belvin, Dir., Herty Laboratory, P.O. Box 1963, Savannah, Georgia.

Vice Chairman—Reland Westgate, Georgia Pacific Corporation, P.O. Box 1350, Savannah, Georgia.

Sec.-Treas.—Ralph Peter, Athens–Macon Research Center, School of Forestry, University of Georgia, Athens, Ga.

Trustee—A. M. Herrick, Forestry School, University of Georgia, Athens, Georgia.

Trustee—Rufus Page, Georgia Forestry Commission, P.O. Box 1183, Macon, Ga.

Trustee—Raymond L. Osborne, 2174 Brook Valley Lane N.E., Atlanta 5, Georgia.

Trustee—Ben M. Turner, Asst. Sec. & Treas., Cordele Sash, Door & Lbr. Co., Cordele, Ga.

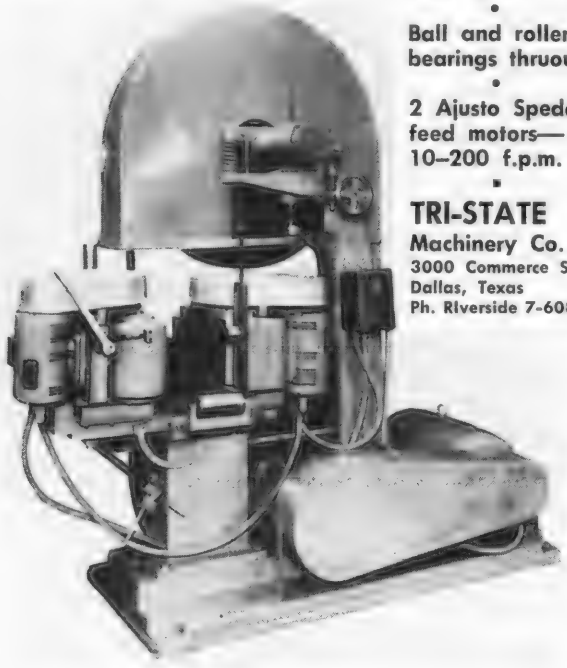
UPPER MISSISSIPPI

Chairman—Paul H. Lane, Lake States Forest Exp. Sta., Northern Lakes Forest Res. Cen., Court House Annex, Wausau, Wisconsin.

NEW - 36" Tilting Band Resaw

Outstanding flexibility — Superior performance. Also available as Band Ripsaw.

Write, wire or phone for details.



Feedworks tilt full 45°

•

15 and 20 h.p. drive motor

•

Ball and roller bearings thruout

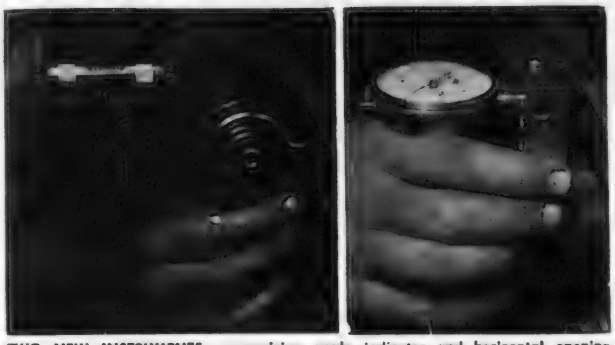
•

2 Ajusto Spede feed motors— 10–200 f.p.m.

•

TRI-STATE
Machinery Co.
3000 Commerce St.
Dallas, Texas
Ph. Riverside 7-6089

NOW! Take the "Guesswork" Out of Veneer Cutting!



TWO NEW INSTRUMENTS, a precision angle indicator and horizontal opening indicator, eliminate "rule of thumb" methods for setting the angle of the knife and the horizontal opening between knife edge and nosebar on veneer lathe or slicer.

SINCE introducing these 2 new tools for precision cutting of veneers in January, they have been ordered and put into use in both softwood and hardwood veneer plants in every section of the U. S. and Canada — from British Columbia to South Carolina, from California to Ontario.

At a recent meeting one producer observed, "It doesn't make any difference how experienced the operator, there comes a time when he gets into trouble for some reason or other and he just can't get back. If he has some standards such as these instruments, they would help him correct his trouble."

With these instruments, even a novice can make accurate adjustments on lathe or slicer and cut good veneer consistently.

For literature and prices write:

WFM
WISCONSIN FOUNDRY AND MACHINE COMPANY
623 E. Main ST. Madison, Wis

WITH THE DELMHORST KIL-MO-TROL

The kiln keeps operating . . .

You stay outside and measure moisture content of lumber to be used in production while it is drying in the kiln!

KIL-MO-TROL

- **SAVES HEAT—No overdrying, kiln is shut down the moment lumber is dry.**
- **SAVES TIME—No need to enter kiln to weigh sample boards.**
- **SAVES LUMBER—Eliminates sample boards, tests made directly on production lumber.**

For complete information on KIL-MO-TROL and other moisture problems, write to:

Delmhorst Instrument Co.

619 Cedar Street
BOONTON, NEW JERSEY

Manufacturers of Moisture Testing Equipment Since 1935

For a *truly* good floor

NORTHERN HARD MAPLE

truly economical

truly modern

truly resilient

★

MAPLE FLOORING MANUFACTURERS ASSN.

CHICAGO 1, ILLINOIS

Vice Chairman & Membership Chairman—Wayne L. Meek, c/o Minn. & Ont. Paper Co., Research Division, International Falls, Minn.

Secretary—Leonard A. Ropella, Roddis Plywood Corporation, Marshfield, Wisconsin.

Treasurer—S. H. Wise, Dev. Dept., Wood Conversion Co., Cloquet, Minn.

Trustee—Henry C. Crandall, Tech., Dir., Mosinee Paper Mills Co., Mosinee, Wisconsin.

Trustee—Walter B. Wallin, School of Forestry, University of Minnesota, St. Paul 1, Minnesota.

FPRS Divisions

CHEMICAL UTILIZATION

Chairman—Dr. Irwin Pearl, Institute of Paper Chemistry, Appleton, Wisconsin.

Vice Chairman—Frederick Perry, Arthur D. Little, Inc., 30 Memorial Dr., Cambridge 42, Mass.

Secretary—Dr. Jerry Saeman, Forest Products Laboratory, Madison, Wisconsin.

GLUES AND GLUING

Chairman—Richard F. Blomquist, U. S. Forest Products Laboratory, Madison 5, Wisconsin.

Vice Chairman—Dr. Ben S. Bryant, Asst. Prof. of Wood Tech., College of Forestry, University of Washington, Seattle 5, Washington.

SECTION REPRESENTATIVES

Carolina-Chesapeake—Richard Thomas, North Carolina State College

Eastern Canadian—C. Ward Peterson, Canadian Forest Products Laboratory.

Great Lakes—Wayne Hutchins, American Seating Company.

Inland Empire—Ben Jayne, State College of Washington.

Mid-South

Midwest

Northeast—Charles B. Hemming, U. S. Plywood Corporation.

Northern California

Northern California—E. F. McDade, Fluor Products, Santa Rosa, Calif.

Ohio Valley—Earl Bell, Gamble Bros., Inc.

Pacific Northwest—A. H. Rauch, U. S. Plywood Corp.

Pacific Southwest—Jack Layman, Monsanta Chemical Co.

Rocky Mountain—Robert Hudson, Best Wood Products Co.

Southeastern—Dean B. Richards, Alabama Polytechnic Institute.

Upper Mississippi Valley—Leonard Ropella, Roddis Lumber & Veneer Co.

INDUSTRY–EDUCATION

Chairman—Everett Ellis, University of Michigan, School of Natural Resources, Ann Arbor, Mich.

LOGGING

Chairman—L. N. Ericksen, P.O. Box 245, Berkeley, Calif.

Vice-Chairman—Emanuel Fritz, 102 The Uplands, Berkeley 5, Calif.

Technical Committee

J. A. Doyle, Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Ottawa, Ont., Canada

Prof. R. F. Grah, University of California, School of Forestry, 243 Walter Mulford Hall, Berkeley 4, Calif.

R. O. Gustafson, Westvaco Experimental Forest, Georgetown, S. C.

David E. Herrick, Carbondale Forest Research Center, Central States Forest Exp. Sta., P. O. Box 760, Carbondale, Ill.

Leland Hooker, Michigan College of Mining & Technology, Houghton, Mich.

Olin A. Lee, Euclid Division, General Motors Corp., Cleveland 17, Ohio

Elmer E. Matson, Pacific Northwest Forest Exp. Sta., Box 4059, Portland 8, Ore.

William McGraw, Roddis Plywood Co., Sault St. Marie, Ont., Canada

Bruce Mety, Southern Lumber Co., 30 Davenport Street, Warren, Ark.

Robert W. Olin, Director of Planning, Potlatch Forests, Inc., Lewiston, Idaho

David B. Turner, McMillen–Bloedel Lumber Co., Port Alberni, B. C., Canada

Yale Weinstein, P. O. Box 1738, Albuquerque, N. M.

LUMBER MANUFACTURING

Chairman—Milton H. Mater, Mater Engineering, P.O. Box 410, Corvallis, Oregon.

Vice Chairman—Paul Heller, Pacifiic Pine Lbr. Co., New Westminister, B. C., Canada.

Secretary—H. I. Winer, School of Forestry, Yale University, New Haven 11, Connecticut.

Subcommittee on Lumber Manufacturing Division Clearing House Activities

Chairman—Norman Taylor, % School of Business Admin., University of Oregon, Eugene, Oregon.

MERCHANDISING

Chairman—William B. Lloyd, Dept. of Forest Products, Michigan State University, East Lansing, Michigan.

Vice Chairman—L. J. Fitzpatrick, J. J. Fitzpatrick Lbr. Co., 5001 University Ave., Madison 5, Wisconsin.

Technical Committee

John Reno, Pacific Lumber Company, 35 E. Wacker Drive, Chicago 1, Illinois.

Roy M. Carter, School of Forestry, North Carolina State College, Raleigh, North Carolina.

PACKAGING

Chairman—Karl Bollerslev, 1101 Latch, Boise, Idaho.

QUALITY CONTROL

Chairman—Dr. John R. Stillinger, Technical Director, Cascades Plywood Corporation, Lebanon, Oregon.

Vice-Chairman—Prof. Aubrey E. Wylie, Department of Forest Products, B–4 South Campus, Michigan State University, East Lansing, Michigan.

VENEER AND PLYWOOD

Chairman—John F. Lutz, U. S. Forest Products Lab., Madison 5, Wisconsin.

WOOD COMPOSITION BOARD

Chairman—James R. Roberts, U. S. Gypsum Corporation, 1423 S. Norman Dr., Palatine, Ill.

Vice Chairman—A. L. Mottet, International Paper Company, Long–Bell Division, P.O. Box 1079, Longview, Washington.

Steering Committee

E. S. Johnson, North Carolina State College.

Wayne Lewis, U. S. Forest Products Laboratory.

H. C. L. Miller, Miller–Hofft Corp.

James Hamilton, Mich. College of Mining & Technology.

George Marra, Wash. State Institute of Technology.

WOOD DRYING

Chairman—Eric L. Ellwood, Forest Products Lab., Univ. of California, 1301 South 46th St., Richmond 4, Calif.

Vice Chairman—Ralph Millett, Seasoning Research, Canadian Forest Products Lab., Ottawa, Ont., Canada.

Sec'y.-Treas.—Harvey H. Smith, Pac. SW Forest & Range Exp. Sta., P. O. Box 245, Berkeley, California.

Past Chairman—J. M. McMillen, U. S. Forest Products Laboratory, Madison, Wisconsin.

"News Digest" Subcommittee

Chairman—R. Rietz, U. S. Forest Products Laboratory, Madison 5, Wisconsin.

R. Page, C. Danielson, F. Nord, W. E. Munson, P. M. Williams, Jr.

Annual Status Subcommittee

Chairman—J. M. McMillen, U. S. Forest Products Laboratory, Madison 5, Wisconsin.

S. B. Preston, C. J. Kozlik.

Abstracting Subcommittee

Chairman—S. B. Preston, School of Natural Resources, University of Michigan, Ann Arbor, Michigan.

H. E. Troxell, F. W. Guernsey.

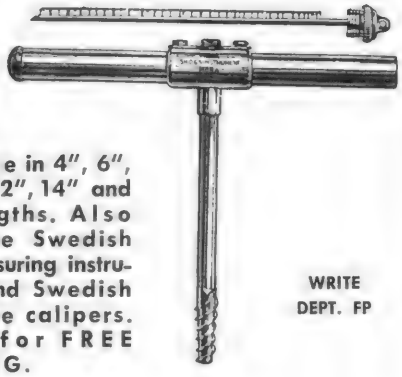
Wood Drying Organizations Subcommittee

Chairman—E. M. Conway, Lumber Drying Specialty Co., 1525 Jefferson Street, Grand Rapids, Michigan.

Precision Tools for Foresters

GENUINE SWEDISH

INCREMENT BORERS



Available in 4", 6", 8", 10", 12", 14" and 16" lengths. Also available Swedish bark-measuring instruments and Swedish steel tree calipers. Write for FREE CATALOG.

WRITE DEPT. FP

Sandvik STEEL INC.

SAW & TOOL DIVISION

1702 NEVINS ROAD FAIR LAWN, N. J.

Simpson land and plant resources are being managed for permanence in Washington, Oregon and California forest communities.

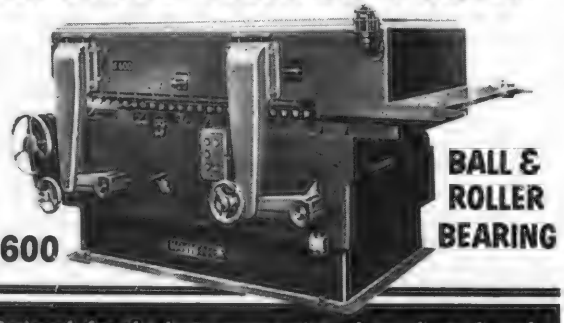
SIMPSON TIMBER COMPANY

Established in 1895

WHITNEY *New-matic*

POWER FEED FACER

with the Human Touch



S-600

BALL & ROLLER BEARING

Designed for the basic preparation of rough stock and for straightening warped lumber or panels before further machine operations. Patented feed belt has molded rubber air cushioned fingers which duplicate mechanically the age old method of feeding a hand jointer. Yielding to the varying thicknesses of lumber these sensitive rubber fingers give the WHITNEY S-600 FACER the Human Touch.

BAXTER D. WHITNEY & SON, INC.

Greensboro, North Carolina, U. S. A.

Cascades Plywood Corporation

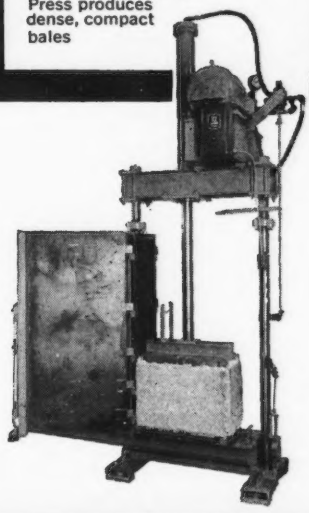
Manufacturers of Douglas fir plywood and Lebanite (smooth-two-sides hardboard)

General office: Public Service Building, Portland, Oregon

Plant at: Lebanon, Oregon

PROFIT FROM WOOD WASTE with CONSOLIDATED BALERS

Duplex Double Chamber Hydraulic Press produces dense, compact bales



Shavings, fibers, wood flour and chips can be turned into a steady source of considerable profit with a modern, low-cost Consolidated hydraulic baling press.

The Consolidated Duplex reduces high-speed baling to practically a push-button operation with complete safety, economy and efficiency, lowest operating costs.

Dense, compact bales sell more easily to poultry and dairy farmers, paper mills, hardboard, particle board and molded products manufacturers, nurserymen, florists, etc.

There is a Consolidated all-steel hydraulic baling press to meet your every need – write for free catalog today.

- Loads and compresses simultaneously
- Over 35 dense, compact bales per hour
- Lowest shipping and handling costs
- Lowest operating costs

Consult Consolidated on all hydraulic equipment problems – no obligation

CONSOLIDATED
BALING MACHINE COMPANY
195–197 Sixth Street
Brooklyn 15, N. Y.

H. H. Smith, W. R. Smith, C. W. Heffner, J. B. Huffman, W. J. Tomford, E. F. Rasmussen, H. B. Gatslick, J. Devine, C. J. Kozlik.

Wood Drying Film Subcommittee

Chairman—J. I. Zerbe, National Lumber Mfrs. Assoc., 1319 18th Street, N. W., Washington 6, D. C.

W. B. Wallen, N. C. Higgins, L. Leney, C. Skaar.

Wood Moisture Survey Subcommittee

Chairman—J. Bethel, Nat'l Science Foundation, Washington 25, D. C.

W. Smith, H. Smith.

Other Committee Members

W. J. Delmhorst, R. H. Elliott, A. C. Knauss, J. D. Irwin, D. B. Richards.

WOOD FINISHING

Chairman—Donald G. Lubeck, Hammond Organ Co., 2915 N. Western Avenue, Chicago 18, Illinois.

Vice Chairman—Clark Hatcher, Drexel Furniture Company, Drexel, North Carolina.

Subcommittees

Education

John D. Sullivan, Asst. Prof. Wood Technology School of Forestry, Duke University, Durham, North Carolina.

Interior Finishing Materials

F. H. Thomas, Sherwin–Williams Co., 11541 S. Champlain, Chicago 28, Illinois.

Exterior Finishing Materials

Neil B. Garlock, Nat'l Paint, Varnish & Lac. Assn., 1500 Rhode Island Ave., N.W., Washington 5, D. C.

Foreign Developments

M. J. Merrick, Head, Research Dept., The Furniture Development Council, 2–4 Dalmeny Avenue, London, England.

WOOD MACHINING

Chairman—Robert J. Hoyle, Jr., Research Department, Potlatch Forests, Inc., Lewiston, Idaho.

Vice Chairman—Norman C. Franz, University of Michigan, 3311 Dale View Dr., Ann Arbor, Michigan.

WOOD PRESERVATION DIVISION

Chairman—R. H. Bescher, Koppers Company, Inc., Wood Preserving Division, Pittsburgh 19, Pa.

Vice Chairman—Harry Troxell, Asst. Prof. of Wood Tech., Colorado A & M College, School of Forestry, Ft. Collins, Colorado.

NOW–CHECK ACCURACY WHILE YOU CHECK MOISTURE!

New Electronic Moisture Registers have first "built-in standard" in a 3-second, portable moisture tester.

NOW DIAL ACCURACY IS ASSURED, even under the extremes of production-line use. With *self-checking standard,* Moisture Register's new Model 5's are checked and adjusted for calibration accuracy right on the job – by any untrained operator. He simply fits electrode to standard. Then with new trimmer he sets dial for perfect alignment. Gives calibration adjustment *in the field.* You get practical accuracy down to 0% ... 3-second spot tests for moisture wherever your product may be. Portable, light weight, battery operated, new rugged construction with miniature tube. Factory-set to your needs.

For faster testing of—

- Hard and soft woods
- Peeled log to finished product
- Lumber, cabinets, furniture, veneer, plywood

SEND FOR NEW TECHNICAL DATA and information on 2-week free trial.

ELECTRONIC MOISTURE REGISTER *Instruments*

Moisture Register Company, Dept. FP
P. O. Box 910, Alhambra, California
Please send data on new Model 5's.

We are testing _____
in moisture range from ____% to ____%
Firm _____
By _____ Title _____
Address _____
City _____ State _____

For SPECIALIZED Inspection Service . . . Contact

—WILLIAMS—

- Inspection of cross ties, lumber, piling, poles, cross-arms, and other timber products.
- Inspection of the preservative treatment of these timber products.
- Analyses of wood preservatives.
- Consultation and Specification Writing.

Our years of experience is your safeguard.

A. W. Williams Inspection Co., Inc.

Main Office and Laboratories: Mobile, Ala.
New York • St. Louis • Portland
ESTABLISHED 1921—MEMBER A.C.I.I.
Inspectors Stationed Throughout United States.

GRANT B. SHIPLEY

Consulting Engineer

3010 KOPPERS BUILDING

PITTSBURGH 19, PENNSYLVANIA

Wood Treating Plants
Mining Plants

PAUL WATTS, INCORPORATED

Distributors and Sales Engineers . . . Forest Products

Furniture Dimension—Cut Stock—Box Shook—Pallets—Lumber

304 Keith Building • MAin 1-5680

Cincinnati 2, Ohio

Repels, kills Chiggers, Ticks, Mosquitos, Black Flies. Contains 5 basic repellents proved best by U.S. Army. Used by national and state Wildlife Services, loggers, etc. Harmless to humans and animals. One spraying protects all day. America's No.1 spray-on repellent.

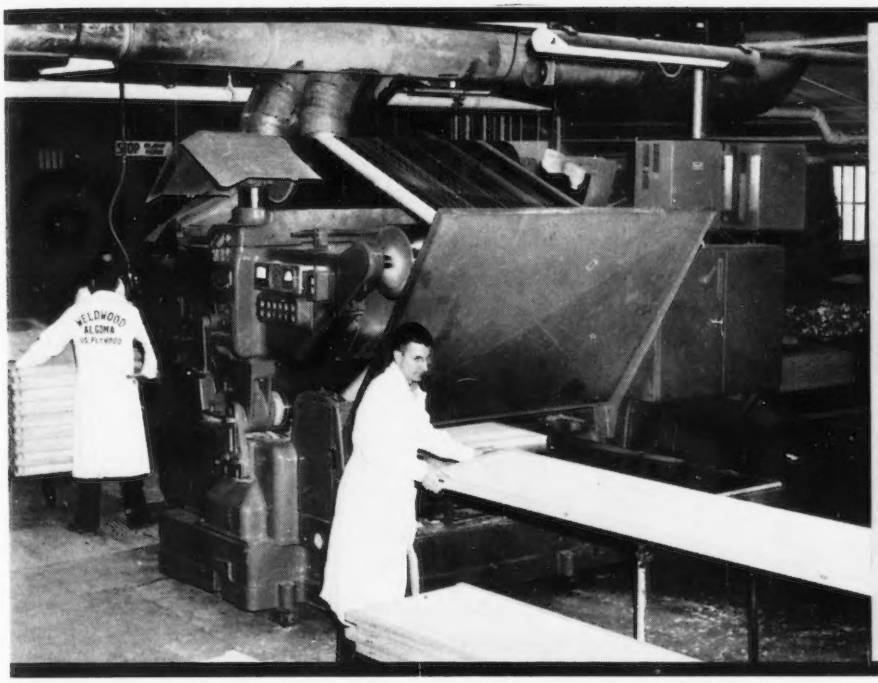
COMMENDED BY PARENTS MAGAZINE

MINE SAFETY APPLIANCES CO.
54 Branches Everywhere
Home Office: Pittsburgh, Pa.

Index to Advertisers

	Page
Allied Chemical Corp., Plastics & Coal Chemicals Division	13-A
American Cyanamid Co.	2nd Cover
American Defibrator, Inc.	74-A
American–Marietta Co.	17-A
Behr–Manning Co.	8-A
Black Brothers Co.	3-A
CARADCO, Inc.	90-A
Cascades Plywood Corporation	94-A
Catalin Corporation of America	15-A
CKL Machinery Co.	88-A
Coe Manufacturing Co.	66-A
Consolidated Baling Mach. Co.	95-A
Delmhorst Instrument Co.	92-A
Drake Corporation	4-A
Ekstrom, Carlson & Co.	4th Cover
Fasterner Corporation	76-A
Gaiennie Wholesale Lumber Co.	32-A
Gamble Brothers	32-A
Greenlee Bros. & Co.	6-A
Hawker Manufacturing Co.	82-A
Heil Company, The	83-A
Hooker Chemical Co.	62-A
Independent Nail & Packing Co.	86-A
Kirk & Blum Mfg. Co.	12-A
Kohler–Joa Corporation	14-A
Kvalheim Machinery Co.	85-A
Lilly Varnish Co.	24-A
Lodge & Shipley Co.	16-A
Mann–Russell Electronics	18-A
Maple Flooring Mfrs. Assoc.	92-A
Mater Engineering	32-A
Mater Machine Works	1-A
Mattison Machine Works	3rd Cover
Mereen–Johnson Machine Co.	56-A
Merit Products, Inc.	9-A
Moisture Register Co.	95-A
Moore Dry Kiln Co.	64-A
National Casein Company	19-A
Newman Machine Company	88-A
Oliver Machinery Company	53-A
Orton Machine Works	90-A
Pasadena Hydraulics, Inc.	88-A
Perkins Glue Co.	5-A
Plastics & Coal Chemicals Div., Allied Chemical Corp.	13-A
Potlatch Forests, Inc.	7-A
Reichhold Chemicals, Inc.	10-A, 11-A
B. M. Root Company	60-A
Roto Finishing Systems	78-A
Sanovik Steel, Inc.	94-A
Saranac Machine Co.	80-A
Sel-Set Machinery Corporation	2-A
Grant B. Shipley	96-A
Simpson Timber Co.	94-A
Soderhamn Machine Mfg. Co.	21-A
Southern Screw Company	20-A
Standard Dry Kiln Co.	23-A
Stetson–Ross Machine Co.	58-A
Sumner Iron Works	22-A
James L. Taylor Mfg. Co.	81-A
Tri-State Machinery Co.	92-A
Union Tool Corporation	87-A
United Shoe Machinery Corp.	70-A
U. S. Plywood Corporation	48-A
Universal Door Carrier, Inc.	90-A
Washington Iron Works	31-A
Paul Watts, Inc.	96-A
Whitmire Research Laboratories (Mine Safety Appliances Co.)	96-A
Baxter D. Whitney & Son, Inc.	94-A
A. W. Williams Inspection Co.	96-A
Williams Patent Crusher & Pulv. Co.	77-A
Williams–White & Co.	79-A
Wisconsin Foundry & Machine Co.	92-A
S. A. Woods Machine Co.	68-A
Wood Treating Chemicals Co.	84-A

new sanding method improves accuracy, increases production, reduces belt costs



SPECIFICATIONS

Abrasive belt length	20 ft 3 in.
Machine size	36 in. capacity
	48 in. capacity
	60 in. capacity
	72 in. capacity

Feed Roll Speed . . . available from 1 to 100 fpm and up—according to your requirements.

MATTISON NO. 456 WIDE BELT SANDER SIZES TO .0015" AT FAST FEEDS IN EITHER DIRECTION

Here's a new, high-production method for sanding core stock, door panels, and other flat work to precision finish and uniform thickness.

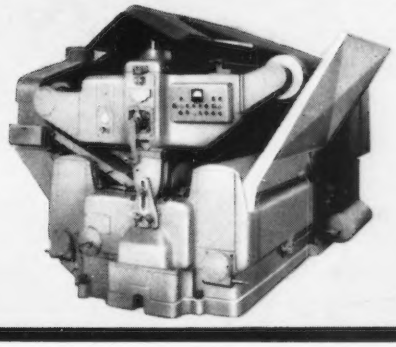
Rigidly constructed of heavy Meehanite metal, the Mattison No. 456 wide belt sander pulls up to 150 hp without vibration—maintains positive settings for sizing hardest stock to within .0015 in. over maximum width and full length. Feed rolls operate in either direction at fast feeds—let you rough, reset, and finish without costly downtime.

Unique four-roll head prevents transfer of motor pulsations to work finish. Long 20 ft belt is flexed and cooled as it cuts, providing freer cutting action and longer belt life. Belt changes are fast and easy—take only minutes.

EXAMPLE: At Algoma Plywood & Veneer Co., Algoma, Wisconsin, producing accurate glue-bond surfaces on edges and corners of surface door cores, bonded cupboard door cores, and similar products is a tough sanding job that requires unusual machine performance. After an intensive search for the right machine, Algoma found that no other sander could match the No. 456 for accuracy and productivity.

In a recent letter, Mr. R. P. Fulwiler, Algoma's president and general manager, said: "Since its installation, our Mattison has been running two shifts a day entirely on core stock, giving us uniform thickness throughout the core equal to any precision-type finish planer. Also, we are getting top production and added economies in sandpaper and reduced maintenance, helping to keep our sanding costs low."

To investigate first hand the production advantages of this new wide belt sanding method, call your Mattison machinery representative.



MATTISON

WOODWORKING MACHINERY

MATTISON MACHINE WORKS ROCKFORD, ILL. U.S.A.

"Built better . . . to produce better quality"

Mattison Machine Works
545 Blackhawk Park Avenue
Rockford, Illinois

Gentlemen: Please send literature describing your No. 456 Wide Belt Sander.

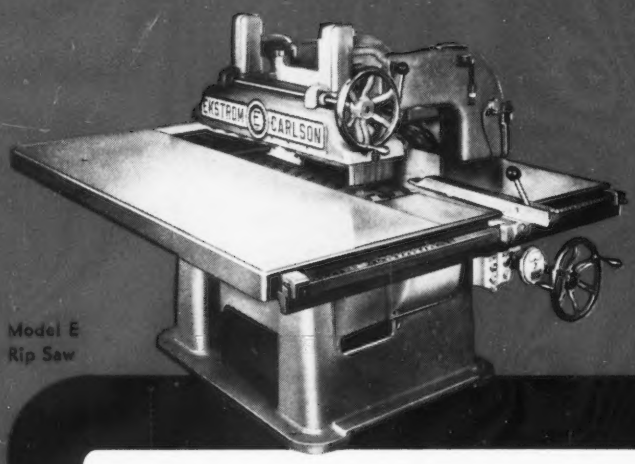
Name_____

Firm_____

Address_____

City_____ Zone____ State_____

EKSTROM CARLSON



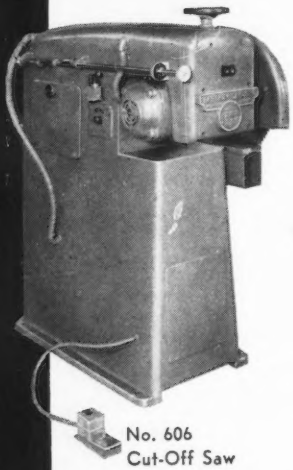
Model E
Rip Saw

HIGH QUALITY WOODWORKING MACHINES

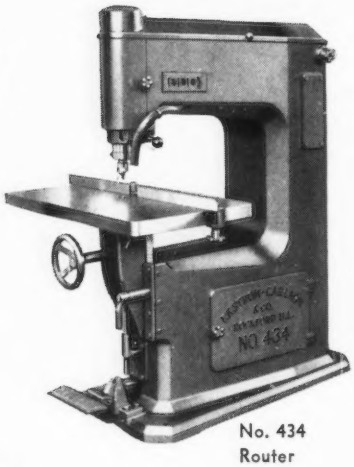
ECCO machines serve you not only today but next week and for years to come. You are assured rugged dependability and trouble-free performance. Operations are performed in less time and minimum cost — you know you have "the best".

ECCO products are the result of over 50 years of successful manufacturing experience. You receive time tested quality, expert craftsmanship, lasting strength and modern design with guaranteed performance and satisfaction.

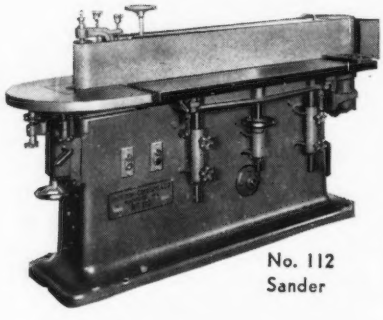
Buy Ekstrom, Carlson Woodworking Machines!



No. 606
Cut-Off Saw

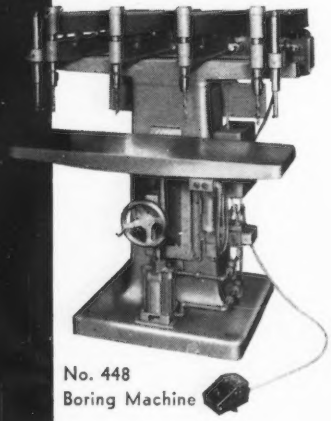


No. 434
Router



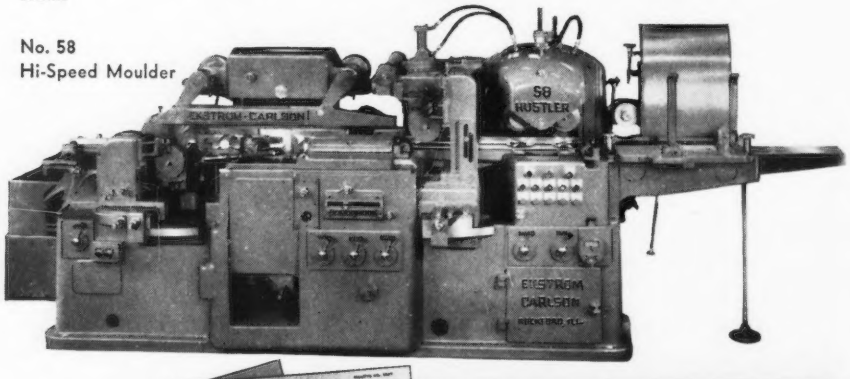
No. 112
Sander

THESE ARE TYPICAL of the complete ECCO line of Machines. Write for bulletins covering all of them.



No. 448
Boring Machine

No. 58
Hi-Speed Moulder



Send for
these BULLETINS
Today

EKSTROM, CARLSON & CO.
1425 RAILROAD AVENUE
ROCKFORD ILLINOIS